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FEASIBILITY STUDY REPORT

FOR

CROSSLEY FARM SITE

**HEREFORD TOWNSHIP, BERKS COUNTY
PENNSYLVANIA**

**EPA WORK ASSIGNMENT NO. 009-RICO-03S2
PROJECT NO. 7525
RAC 3 PROGRAM – CONTRACT NO. 68-S6-3003**

JULY 2001

TETRA TECH NUS, INC.

AR300001

PHIL-14267

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FOR THE
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

JULY 2001

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

This feasibility study (FS) outlining the development and analysis of remedial alternatives for contaminated groundwater, at and in the vicinity of the Crossley Farm Site has been prepared by Tetra Tech NUS, Inc. (TtNUS). The FS was prepared on behalf of the U.S. Environmental Protection Agency (EPA) under Work Assignment 009-RICO-03S2, Contract No. 68-S6-3003. This report was prepared in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and its amendments. Contaminated media and chemicals of concern (COCs) requiring remediation were identified in this FS based on the conclusions of the remedial investigation (RI) for the site.

SITE DESCRIPTION

The Crossley Farm Site is located in the Huffs Church community in Hereford Township, Berks County, Pennsylvania about 50 miles northwest of Philadelphia. The Crossley Farm is an active farm that has historically operated as a dairy and crop farm. The farm is located on a topographic local highland area known as Blackhead Hill. A quarry located on the farm was mined for building stone from approximately 1946 until sometime in the late 1970's. The quarry is no longer in operation however, the farming activities are still ongoing.

From the mid-1960's to the mid-1970's, a local plant reportedly sent numerous drums to the Crossley Farm for disposal. The plant was believed to have used trichloroethene (TCE) and tetrachloroethene (PCE) as degreasers. The drums contained mostly liquid waste and were described as having a distinctive 'solvent' odor. Regulatory involvement at the site began in 1983 when local residents complained to the Pennsylvania Department of Environmental Protection (PADEP) about odors in private water supply wells. Based on subsequent sampling and analysis, PADEP issued a health advisory on groundwater use in the area and recommended boiling water, installing carbon filtration systems, or using bottled water where detected TCE concentrations exceeded 45 ug/l.

A regional hydrogeologic investigation conducted by EPA, in 1988, concluded that the Crossley Farm was a probable source of contamination and hypothesized that likely source areas included either an on-site quarry or borrow pit area. In September 1994, EPA initiated a remedial investigation and feasibility study (RI/FS) for the site. It was soon decided that the investigation and ultimate disposition of the contaminated residential well supply problem (which subsequently became Operable Unit-1 or OU-1) should be expedited and addressed in a focused feasibility study (FFS) prior to the site investigation activities. On June 30, 1997, the EPA signed the

Record of Decision (ROD) for OU-1. The ROD presented the basis for EPA's selection of a point-of -entry treatment system as the interim remedy for contaminated potable sources located within the study area. The ROD called for the systems to be installed on all residential supplies that had been impacted by the site. To date, 44 treatment systems have been installed, including the replacement of older, original equipment installed by EPA in the 1980's.

As a result of information gathered during the RI, a test pit excavated by EPA in December 1997 confirmed the presence of on-site buried drums and associated contaminated soil. The subsequent removal action conducted during the summer of 1998 resulted in the excavation and removal of approximately 1,200 buried drums and 15,000 tons of contaminated soil.

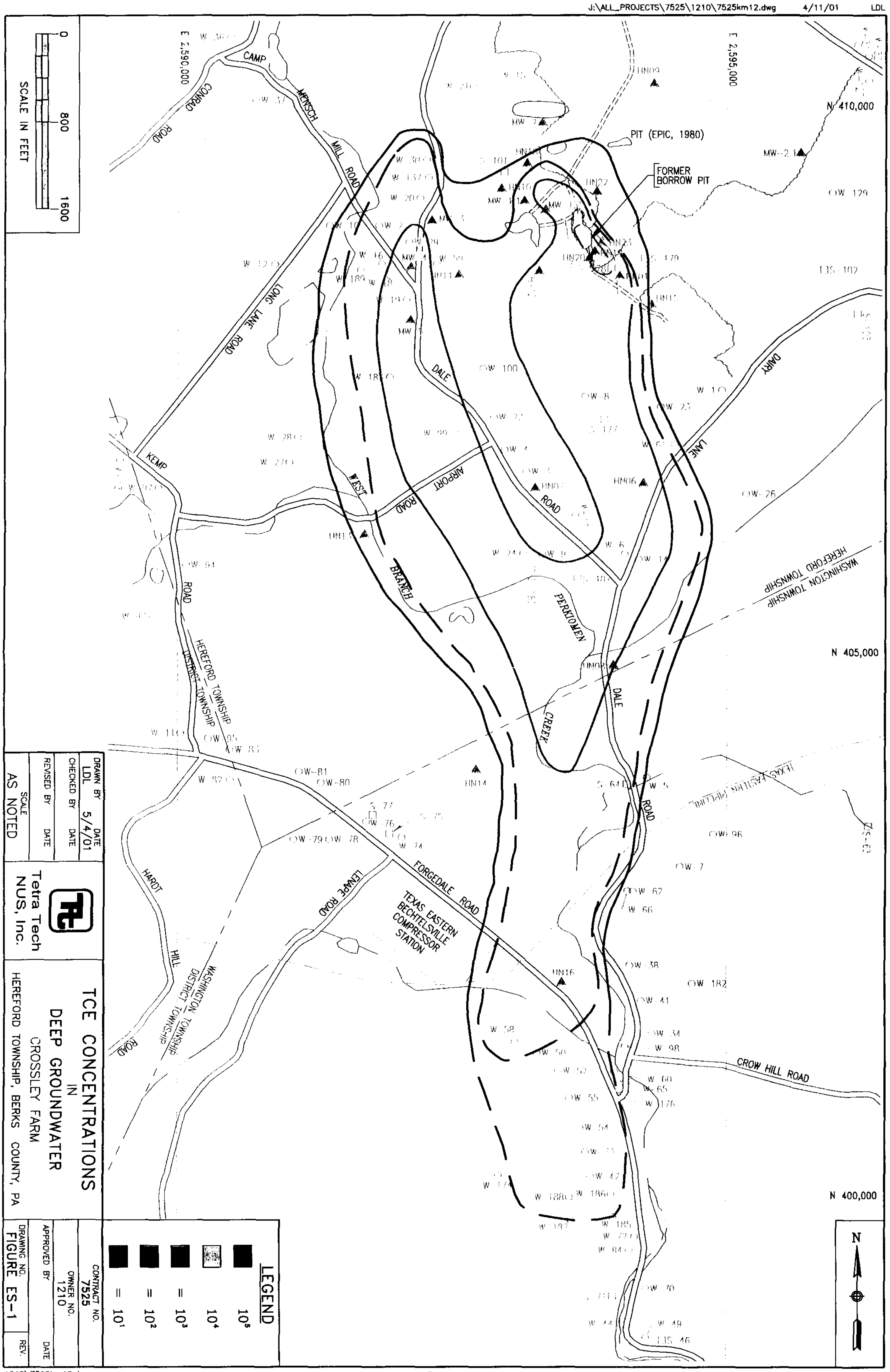
Major findings regarding the nature and extent of contamination at the site, as outlined in the RI Report are as follows:

Groundwater

A large plume of contaminated groundwater emanates from the Crossley Farm and extends downgradient a distance of more than 12,000 feet, into the Dale Valley (see Figure ES-1). The primary contaminants are chlorinated volatile organic compounds (VOCs). TCE is the most common groundwater contaminant, and is so pervasive that the extent of the plume can largely be defined solely on the occurrence of TCE. TCE concentrations range from 190,000 ug/L detected just south of the former borrow pit on Blackhead Hill to less than 10 ug/L at the farthest edges of the plume. Other common VOCs detected at varying concentrations within the plume include PCE and cis-1, 2-dichlorcethene (cis-1, 2-DCE). Many other VOCs were detected less frequently and at generally lower concentrations.

The patterns of groundwater contamination are consistent with the presence of either a dense non-aqueous phase liquid (DNAPL) or high-concentration residual source area atop Blackhead Hill, and an advective, dissolved-phase migrating VOC plume. The highest concentrations of VOCs were detected in wells located approximately 360 feet downgradient of a former borrow pit.

The areal distribution of the groundwater contaminants and the directions of groundwater flow indicated that the former borrow pit area and the Environmental Photograph Interpretation Center (EPIC) pit area are the principal source areas of groundwater contamination (see Figure ES-1).



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CROW HILL ROAD
FORGEDALE ROAD
LENAPE ROAD
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PIT (EPIC, 1980)
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HEREFORD TOWNSHIP
WASHINGTON TOWNSHIP
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The VOC plume is continuing to migrate and expand, and has not reached steady-state conditions. The VOC concentrations in certain downgradient residential wells have increased over time. In addition, one or two (on average) VOC detections have been noted in previously uncontaminated residential potable sources during each semiannual sampling round conducted for the remedial action (RA) for the private water supplies.

Soil

Relatively few organic compounds were detected in site soils or at frequent intervals. The relatively low concentrations of solvent that were detected, however, are interpreted to indicate that little contaminated soil remains at the site to act as a residual source of contamination.

Inorganic chemicals of potential concern (COPCs) for soil were identified in the baseline risk assessment conducted as part of the RI and included aluminum, chromium, iron, manganese, and vanadium for surface and subsurface soils. The RI concluded that none of the metals comprising the COPCs occur at elevated concentrations as a result of, or related to, the unregulated disposal of hazardous waste solvents. Instead their occurrence is interpreted to result from a combination of the natural soil and bedrock mineralogy and from the use of manufactured fertilizers and/or municipal sewage sludge.

Surface Water

A number of VOCs were detected in surface water samples collected from the study area. The VOCs that were detected included TCE, PCE, and cis-1, 2-DCE. The maximum detected TCE and PCE concentrations both occurred at a sampled spring located along the western slope of Blackhead Hill within a topographic draw between the quarry and the Trash Dump. Based on the RI, it is believed that groundwater from both the excavated drum pit area and the former borrow pit flows through this point and is the source of the spring.

Significant concentrations of TCE were detected at sampling points located downgradient of the site.

Semi-volatile organic compounds (SVOCs), pesticides, and polychlorinated biphenyls (PCBs) were detected very rarely and at low concentrations.

Inorganics were abundant and pervasive within the surface waters throughout the study area. The presence of a few of the detected inorganics may be attributable to the site.

Based on the risk assessments presented in the RI, no unacceptable carcinogenic or non-carcinogenic risks were associated with potential exposures to site surface water.

Sediment

VOCs were detected frequently at elevated concentrations within the sediments. The distribution of VOCs within the sediments was very similar to those of surface water.

The RI analytical data suggested that the site may be a source of some metals. However, the presence of certain inorganics in sediment does not appear to be the result of the disposal of hazardous waste materials at the site.

Based on the results of the human health risk assessment, a potential non-carcinogenic risk from exposure to sediment material at location SD-2 may exist. SD-2 is located about 1,400 feet downgradient from an on-site stock pond located on the north side of the farm near Dale Road.

IDENTIFICATION OF MEDIA OF CONCERN AND COC'S

The RI identified media and chemicals of concern to be addressed in the FS. The media of concern at the site is groundwater. Soil and sediment were not included in the FS because the COCs identified for these media are not related to the hazardous waste disposal activities conducted at the site. The risk assessment identified unacceptable risk levels for untreated residential well supplies. However, affected residential wells are currently addressed by the ROD for OU-1 and are therefore not included as a media of concern in this FS.

COCs for site groundwater were determined based on a screening of the detected maximum concentrations with federal criteria (i.e., Maximum Contaminant Levels (MCLs)) and background concentrations. For site groundwater, the COCs were TCE and PCE.

DESCRIPTION OF THE FS PROCESS

As outlined in the RI/FS guidance, the development of alternatives for the FS requires: identifying remedial action objectives; identifying potential treatment, resource recovery, and containment technologies that will satisfy these objectives; screening the technologies based on their effectiveness, implementability, and cost; and assembling technologies into alternatives for remediation of the contaminated media at the site. When the alternatives are identified they are screened to reduce the number of alternatives subject to the detailed analysis. During the detailed analysis, the alternatives are analyzed in detail with respect to nine evaluation criteria:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and performance
- Reduction of toxicity, mobility, or volume
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

Typically, state acceptance and community acceptance are addressed in the ROD after comments on the RI/FS report and Proposed Plan have been received.

REMEDIAL ACTION OBJECTIVES

To protect the public and environment from potential current and future health risks, the following remedial action objectives were developed for the Crossley Farm Site FS:

- Limit migration from the site of contaminated groundwater that presents an unacceptable risk.

ALTERNATIVES DEVELOPMENT

Following the technology screening and detailed evaluation, remedial technologies were assembled into alternatives that address contaminated groundwater and the RAOs. These alternatives provide variable levels of protection to human health. The majority of the groundwater alternatives require the collection of additional field data to address information data gaps identified in the RI report. Summaries of the remedial alternatives that are reviewed in this FS are presented below.

Groundwater

Alternative 1 – No Action

The no action alternative was developed as a baseline to which other groundwater alternatives may be compared, as required by the National Contingency Plan (NCP). Under this alternative, no measures would be taken to contain and/or treat the dissolved groundwater plume or the DNAPL source area. No restrictions on the current and/or future withdrawal and use of groundwater beneath the site would be made. Since contaminants would remain in groundwater beneath the site, a review of site conditions and risks would be conducted every 5 years as required by CERCLA.

Alternative 2 – Institutional Controls and Groundwater Monitoring

Under this alternative, restrictions on the withdrawal and use of site groundwater would be placed in the site deeds. Long-term sampling and analysis of groundwater to determine the status of the residual zone and center of the plume, the quality of groundwater beneath the site, and the extent of the plume would be the second component of this alternative. Because contaminants would remain in groundwater at the site, 5-year reviews would be conducted to review site conditions and to determine if the level of contamination poses an increased risk to human health and/or the environment.

Alternative 3 – Groundwater Containment of Center of Plume and On-Site Treatment/Recharge

Alternative 3 would contain the 1,000+ ug/L dissolved TCE plume located immediately downgradient of the farm on Blackhead Hill (i.e., the center of plume) (see Figure ES-1). The captured water would be treated ex-situ and on-site, before it is returned to the aquifer system via an injection well network or a series of recharge trenches/beds. Alternative 3 would consist of the following:

- Pre-design investigation and treatability studies
- Installation of a groundwater well system for hydraulic containment of the center of plume
- On-site groundwater treatment
- Groundwater well network or recharge beds for on-site recharge
- Institutional controls
- Groundwater and surface water monitoring

Based on information obtained during the RI and assumptions made regarding the hydraulic characteristics of the aquifer, it was estimated that a total of 41 wells, placed at depths ranging from 100 feet to 400 feet, would be needed to contain the western and southern perimeters of the 1,000 ug/L TCE plume. The estimated total pumping rate is 320 gallons per minute (gpm). For purposes of the FS, air stripping followed by carbon polishing was the treatment technology selected for Alternative 3.

Alternative 3 would result in the containment and the treatment of a significant portion of the plume that is located beneath the Crossley Farm. That portion of the plume that is contaminated with TCE at levels below 1,000+ ug/L would not be contained, nor would that portion of the plume that is located beyond the Crossley Farm property boundary. Thus, contaminated groundwater outside the proposed capture zone would continue to migrate. The implementation of restrictions on the withdrawal and use of contaminated water would be included for that portion of the site where groundwater is not contained and/or treated. Long-term monitoring would be conducted to evaluate site conditions and risks and to help determine the effectiveness and progress of the remedial action. As contamination would remain on-site, 5-year reviews would also be required.

Alternative 4 – Groundwater Containment of Center of Plume, On-Site Treatment and Discharge to West Branch Perkiomen Creek

Alternative 4 involves the containment and treatment of the same portion of the plume as Alternative 3. The only difference is that the treated water would be discharged directly to the West Branch Perkiomen Creek via a discharge line from the treatment facility to the creek. As part of the monitoring program, the treated water would be sampled on a routine basis to ensure the effectiveness of the treatment process and to monitor the quality of the water being introduced into the creek. The pre-design investigation component of Alternative 4 also includes groundwater modeling to determine the effects of the withdrawal of the estimated 320 gpm of groundwater from the aquifer and its discharge into West Branch Perkiomen Creek. The implementation of institutional controls and long-term monitoring would be the same as for Alternative 3.

Alternative 5 – In-Situ Treatment of Residual Plume

This alternative would reduce contaminant concentrations within that area defined as the DNAPL or residual plume (i.e., beneath and immediately downgradient of the former borrow pit). Contaminated groundwater outside the proposed treatment area would continue to migrate downgradient. As part of the pre-design investigation, groundwater sampling and aquifer characterization would determine the actual presence of the DNAPL, including its vertical and horizontal extent. Under this alternative, an in-situ treatment technology would be selected based on the results of treatability studies conducted during the pre-design investigation. The selected technology would then be used in the field for reduction of TCE and PCE concentrations beneath and adjacent to the borrow pit. Several technologies that have been identified as potentially applicable to the site contaminants and conditions are chemical oxidation and air-sparging/vacuum extraction. For purposes of the FS, chemical oxidation using Fenton's Chemistry was selected as the groundwater treatment technology. Because contamination would continue to exist at the site, institutional controls and long-term monitoring would also be components of this alternative. Five-year reviews would also be conducted as required by CERCLA.

Alternative 6 – Residual/Hot-Spot Plume Pumping and On-Site Treatment/Recharge

This alternative includes remediation of the residual or possible DNAPL (hot spot) area of groundwater contamination. This area of contamination exists below the former borrow pit and immediately downgradient to the south towards existing wells HN-19, HN-20 and HN-23 (see Figure ES-1). For the purposes of this FS, it was assumed that the residual TCE contamination extends to a depth of about 400 feet and its measured concentration range up to 190,000 ug/L. Prior to the actual implementation of any remedial measures in this area, groundwater sampling and aquifer characterization would delineate the complete vertical and horizontal extent of contamination and visually determine if a DNAPL exists. This alternative would capture a majority of the residual material within the plume. Implementation of this alternative may be conducted in a phased approach to minimize additional downgradient movement of the DNAPL and/or residual plume. Under this alternative, there are six main components:

- Pre-design investigation and treatability
- Installation of well(s) for extraction of groundwater from the residual or DNAPL (hot spot) plume
- Treatment of residual extracted groundwater for removal of the primary contaminants of concern
- Recharge of the treated water to the site groundwater aquifer
- Institutional controls
- Periodic monitoring of groundwater to determine the effectiveness of the treatment alternative and to monitor groundwater quality

Treatment of the extracted contaminated groundwater would be conducted on the site probably near the former borrow pit. For purposes of this FS, air stripping followed by carbon polishing was the selected treatment technology. Bench-scale studies would be conducted during the pre-design investigation to select the appropriate treatment technology.

Alternative 7 – Groundwater Containment of Valley Plume, On-Site Treatment and Discharge to West Branch Perkiomen Creek

This alternative would address the plume of TCE-contaminated groundwater that extends from the site downgradient into the valley north of West Branch Perkiomen Creek and eventually on the southern side of the creek into Washington Township. The intent of the remedial alternative is to capture contaminated groundwater originating from the site before it flows into or beneath the West Branch Perkiomen Creek or the unnamed tributary located along the east-southeastern boundary of the plume (see Figure ES-1). The groundwater would then be treated ex-situ prior to discharge into the West Branch.

Groundwater would be contained using a network of wells that would be designed and operated to capture the 1,000 ug/L TCE-contaminated plume throughout the impacted intermediate and deep aquifers that underlies this portion of the Dale Valley. Based on information obtained during the RI and assumptions made regarding the hydraulic characteristics of the valley aquifer system, preliminary calculations determined that two containment systems consisting of 11 wells each would be constructed. Wells would be installed up to 400 feet in depth. The estimated total preliminary pumping rate is about 440 gpm. Groundwater would be conveyed to treatment systems consisting of air strippers and carbon polishing units for on-site treatment. The treated water would be discharged directly to the West Branch Perkiomen Creek. Because contamination would remain in groundwater beneath and downgradient of the site, institutional controls to restrict the use of site groundwater would be necessary. Long-term sampling of both groundwater monitoring and residential drinking wells would also be conducted for the duration of the treatment period. Five-year site reviews would be conducted as required by CERCLA.

Alternative 8 – In-Situ Treatment of Valley Plume

The intent of Alternative 8 is the same as remedial Alternative 7, to capture the contaminated groundwater originating from the site before it flows into or beneath the West Branch Perkiomen Creek or the unnamed tributary located along the east-southeastern edge of the plume (see Figure ES-1). Under Alternative 8, however, contaminated groundwater within the valley plume would be treated using an appropriate in-situ technology. For purposes of the FS, chemical oxidation using Fenton's Chemistry to oxidize the TCE and PCE into non-hazardous, naturally occurring acids that are further reduced to carbon dioxide, oxygen, and water, was preliminarily selected as an appropriate technology. Based on preliminary calculations it was estimated that about 100 process injector wells would be installed to treat the two branches of the 1,000 ug/L contaminant plume before it crosses the West Branch Perkiomen Creek. Selection of the appropriate technology would be based on in-field testing conducted during the pre-design investigation phase. Because the residual area of TCE contamination would not be addressed by this alternative, it is expected that there would be a continuing source of TCE contaminants to the downgradient aquifer system.

Long-term monitoring of groundwater and residential wells would be conducted both during and after the treatment period. The sampling program would monitor the level of contamination, the extent of the plume, and the effects of the treatment system. Institutional controls to restrict the withdrawal and use of groundwater impacted by the site would also be implemented under Alternative 8. Because contamination would remain, 5-year reviews would also be conducted.

Alternative 9 – Groundwater Containment of Center of the Plume and Valley Plume

The intent of Alternative 9 is to remediate the 1,000 ug/L plume of TCE-contaminated groundwater both in the upper area of Blackhead Hill (i.e., the center of plume) and the portion of the Dale Valley before it flows beneath the West Branch Perkiomen Creek (see Figure ES-1). The Dale Valley portion is that area located just before the plume flows into or beneath the West Branch Perkiomen Creek or the unnamed tributary located along the east-southeastern boundary of the plume. The implementation of Alternative 9 is dependent on the results of additional fieldwork to determine the effect on downgradient residential wells of the withdrawal and discharge of approximately 320 gpm from the upgradient aquifer and the additional withdrawal of 440 gpm of groundwater from the Dale Valley area. It was assumed that Alternative 9 would include the construction and operation of at least two separate groundwater containment and treatment systems. The first would be similar to Component 2 of Alternative 3 for the center of plume area, and the second system would be similar to Component 2 of Alternative 7.

Because some contamination would remain for a period of time, Alternative 9 would also include the placement of institutional controls to restrict the use and/or withdrawal of impacted, untreated groundwater. In addition, long-term monitoring and 5-year data reviews would be conducted.

COMPARATIVE ANALYSIS OF ALTERNATIVES

Detailed evaluations of remedial alternatives were performed for this FS in accordance with the requirements of the NCP and the EPA RI/FS Guidance Document. As part of the detailed analysis, the remedial alternatives were compared to identify differences and compare how site contaminant threats are addressed. The following seven criteria, as established by the NCP, were used for the detailed analysis of alternatives:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of mobility, toxicity, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

Two other evaluation criteria, state and community acceptance will be addressed following receipt of comments submitted during the public comment period, following presentation of the Proposed Action Plan. A summary and comparative evaluation of the remedial alternatives for groundwater is presented in Table ES-1.

TABLE ES-1

COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES

FEASIBILITY STUDY

CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PA

CRITERION	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 INSTITUTIONAL CONTROLS AND MONITORING	ALTERNATIVE 3 CONTAIN, TREAT AND ON-SITE RECHARGE	ALTERNATIVE 4 CONTAIN, TREAT AND OFF-SITE RECHARGE	ALTERNATIVE 5 IN-SITU TREATMENT OF RESIDUAL/HOT SPOT PLUME	ALTERNATIVE 6 RESIDUAL/HOT SPOT PLUME PUMP AND TREAT, ON-SITE RECHARGE	ALTERNATIVE 7 GROUNDWATER CONTAINMENT OF VALLEY PLUME, ON-SITE TREAT AND OFF-SITE DISCHARGE	ALTERNATIVE 8 IN-SITU TREATMENT OF VALLEY PLUME	ALTERNATIVE 9 CONTAINMENT OF CENTER OF PLUME AND VALLEY PLUME, TREAT AND OFF-SITE DISCHARGE
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT									
Human Health	Provides no additional protection against human exposure to contaminated groundwater. Carcinogenic and non-carcinogenic risks exceeding EPA's target risk range would remain. No institutional controls to restrict use of untreated contaminated site groundwater for drinking water. No actions taken to reduce contaminant dispersion from center of plume, residual zone or valley plume.	Institutional controls would minimize potential exposure to site groundwater by prohibiting its use as drinking water. Groundwater monitoring would provide information regarding extent and concentration of contaminant plumes.	Over time will prevent exposure to TCE concentrations greater than 1,000 ug/l downgradient of site. Institutional controls would minimize potential exposure to site groundwater during the treatment period by prohibiting its use for drinking water. Monitoring would provide information regarding performance of remedial alternative and extent of untreated portion of site plume.	Same as Alternative 3.	Provides in-situ treatment of possible DNAPL source area. Natural degradation may reduce downgradient groundwater contaminant concentrations on-site and off-site, though over an extended period of time. Institutional controls and monitoring same as Alternative 3.	Provides collection and ex-situ treatment of possible DNAPL source area. Treated water would be returned on-site. Natural degradation may reduce groundwater contaminant concentrations on-site and off-site, though over an extended time period. Institutional controls and monitoring same as Alternative 3.	Would provide limited protection as majority of on-site and off-site plumes would not be contained and/or treated. Would provide collection and treatment of a portion of valley plume (>1,000+ug/l TCE). Institutional controls and monitoring same as Alternative 3.	Same as Alternative 7, however treatment may not reduce contaminant levels to below MCLs.	Would provide higher level of protection as groundwater contaminated with TCE >1,000 ug/l on Blackhead Hill and in Dale Valley would be captured and treated. Institutional controls and monitoring same as Alternative 3.

TABLE E
COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
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CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PA

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OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT (continued)									
Environment	No means of evaluating protection.	No additional protection provided to environmental receptors.	Over time would provide some protection as groundwater contaminant levels decreased.	Same as Alternative 3.	Over time would provide protection as source of contamination would be destroyed.	Same as Alternative 5.	Would not be protective of on-site ecological receptors.	Same as Alternative 7.	Same as Alternative 3
COMPLIANCE WITH ARARs AND TBCs									
Chemical-Specific	Would not comply with state groundwater quality standards or statutory requirements.	Same as Alternative 1.	Implementation of this alternative would result in containment and treatment of TCE dissolved plume of 1,000 ug/l or greater concentration. Treatment would achieve ARAR for captured groundwater, only. On-site and off-site TCE plumes less than 1,000 ug/l would not comply, though over extended time period concentrations should decrease.	Same as Alternative 3.	Dissolved plume would not comply; over time residual source would be removed; dissolved plume concentrations should decrease.	Same as Alternative 5. Extent of untreated portion of site plume.	On-site dissolved and residual groundwater plume concentrations would not be in compliance. Groundwater downgradient of valley treatment zone should comply over time.	Same as Alternative 7.	Would result in containment and treatment of TCE plume >1,000 ug/l. Lower concentrations plumes should comply over time.

TABLE ES-1
COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PA

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COMPLIANCE WITH ARARs AND TBCs(continued)									
Location-Specific	Not applicable	Not applicable	Would comply	Would comply	Would comply	Would comply	May not comply	May not comply	May not comply
Action-Specific	Not applicable	Monitoring activities would comply with appropriate federal and state requirements.	Treatment processes for captured portion of plume would comply.	Same as Alternative 2.	Treatment processes for residual plume would comply.	Same as Alternative 5.	Treatment processes for portion of Valley plume would comply.	Same as Alternative 7.	Would comply
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT									
Treatment Process Used	None	None	Air Stripping with Activated Carbon Polishing	Same as Alternative 3.	Chemical Oxidation Using Fenton's Reagent	Same as Alternative 3	Same as Alternative 3.	Chemical Oxidation Using Fenton's Reagent	Same as Alternative 3
Amount Treated or Destroyed	None	None	Approximately 122 million gallons of contaminated groundwater, containing 1,018 lbs. TCE plus other VOCs remediated per year.	Same as Alternative 3.	Treatment of the residual source area (i.e., possible DNAPL) would result in the reduction of a portion of the TCE contaminated groundwater. Due to limited data on vertical and horizontal extent, quantity of contaminants removed/destroyed cannot be determined at this time.	Same as Alternative 5.	Treatment of a portion of the dissolved Valley plume would result in the reduction of some of the contaminated groundwater. Over an extended period of time the amount of contaminant mass removed from the plume would increase. No source reduction.	Same as Alternative 7.	Same as Alternative 3

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REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT (continued)									
Reduction of Toxicity, Mobility or Volume Through Treatment	No reduction, since no treatment would be employed.	Same as Alternative 1.	The groundwater extraction and treatment system would capture a portion of the dissolved plume and remove the VOCs to reduce the toxicity, mobility and volume of contaminated groundwater. Due to unknown quantity of source material beneath the borrow pit, the number of years of treatment to reduce on-site levels below ARARs is unknown.	Same as Alternative 3.	The toxicity and volume of untreated groundwater within the residual zone would be reduced through implementation of Alternative 5. The degree of reduction would be based on the level of effectiveness. Mobility of the residual plume not affected.	Same as Alternatives 5.	The toxicity and volume of groundwater within the valley plume would be reduced. Preliminary design would treat 2,400 gpm. Mobility of plume not affected.	Same as Alternative 7.	Same as Alternative 3 and 7.
Irreversible Treatment	Not Applicable	Not Applicable	Yes, contaminants are removed from groundwater.	Same as Alternative 3.	Yes, contaminants in groundwater are oxidized to non-toxic compounds.	Yes, contaminants are removed from groundwater.	Same as Alternative 6.	Yes, contaminants in groundwater are oxidized to non-toxic compounds.	Same as Alternative 3.
Statutory Preference for Treatment	No	No	Does not treat entire plume.	Does not treat entire plume.	Does not treat entire plume.	Does not treat entire plume.	Does not treat entire plume.	Does not treat entire plume.	Does not treat entire plume.

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LONG-TERM EFFECTIVENESS AND PERMANENCE									
Magnitude of Residual Risk	Existing risks would remain.	Implementation and enforcement of institutional controls would reduce risks from exposure to on-site groundwater. Risks to off-site untreated groundwater would remain.	Groundwater treatment would result in reduction of risks from exposure to a portion of the on-site TCE plume. Over an extended period, until groundwater remediation goals are achieved and natural degradation reduces on-site concentrations, implementation and enforcement of institutional controls would reduce risks from exposure to on-site groundwater.	Same as Alternative 3.	Over time, risk at site would be reduced as source of contamination would be removed; however dissolved plume not treated.	Same as Alternative 5.	Risk at site would remain the same; risk downgradient of treatment zone would be reduced.	Same as Alternative 7.	Same as Alternative 3.

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SHORT-TERM EFFECTIVENESS									
Community Protection	No risk to community anticipated.	No significant risk to community anticipated.	No significant risk to community anticipated. Engineering controls would be used during implementation to mitigate risks.	Same as Alternative 3.	Risk to community should be minimal, additional information on bedrock fracture network and treatment process chemistry required prior to implementation.	No significant risk to community anticipated. Engineering controls would be used during implementation to mitigate risks.	Same as Alternative 6.	Same as Alternative 5.	Same as Alternative 3.
Worker Protection	No risk to workers anticipated if proper PPE is used during long-term monitoring.	Same as Alternative 1	No significant risk to workers anticipated if proper PPE is used during installation and operation of the groundwater extraction and treatment systems and long-term monitoring.	Same as Alternative 3.	No significant risk to workers anticipated if proper PPE is used during installation and operation of the in-situ treatment system and long-term monitoring.	Same as Alternative 3.	Same as Alternative 3.	Same as Alternative 5.	Same as Alternative 3.
Environmental Impacts	None anticipated since no remedial actions would be taken.	None anticipated as remedial measures consist of institutional controls and monitoring.	No adverse impacts to the environment anticipated during construction. Engineering controls would be used during implementation to mitigate risks	Same as Alternative 3.	Additional information on bedrock fracture network required prior to design and implementation to identify required engineering controls to minimize risk.	No adverse impacts to the environment anticipated. Engineering controls would be used during implementation to mitigate risks.	Same as Alternative 6.	Additional information on proposed treatment area geology and hydrogeology needed to identify required engineering controls to minimized risk.	Same as Alternative 3.

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LONG-TERM EFFECTIVENESS AND PERMANENCE (continued)									
Adequacy and Reliability of Controls	Not Applicable.	Long-term enforcement of institutional controls would be required to ensure their effectiveness for preventing use of contaminated groundwater.	Groundwater extraction and air stripping are widely used effective technologies for the remediation of VOC contaminated groundwater.	Same as Alternative 3.	Relatively new treatment process, may not be adequate for extent of DNAPL source area and contaminant levels; has had limited field applications.	Groundwater extraction and air stripping are widely used effective technologies for the remediation of VOC contaminated groundwater. Adequacy of treatment is dependent upon effectiveness of extraction/containment system.	Same as Alternative 6	Relatively new treatment process, has had limited field applications. Adequacy of treatment is dependent upon effectiveness of reagent versus contaminant levels and geology of treatment area.	Same as Alternative 3. and 6
Need For 5-Year Review	Review would be required since groundwater contaminants would be left in place.	Review would be required since groundwater contaminants would be left in place and institutional controls would be implemented.	Review would be required for the duration of the groundwater remediation period since groundwater contaminants would remain above remediation goals and institutional controls would be implemented.	Same as Alternative 3.	Review would be required since dissolved plume not remediated.	Same as Alternative 5.	Review would be required since source area and majority of dissolved plume not addressed.	Same as Alternative 7.	Same as Alternative 3.

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SHORT-TERM EFFECTIVENESS (continued)									
Time Until Remedial Action Objectives Achieved	Not Applicable	1 year until RAO for preventing exposure to site groundwater is achieved. Would not meet RAO for preventing migration of contaminated groundwater.	Will achieve RAO for preventing exposure to site groundwater with 1 year (by institutional controls). Will not achieve RAO of preventing migration of contaminated groundwater as only a portion of the on-site dissolved plume will be contained (1,000+ppb TCE). As no source (i.e. DNAPL zone) removal would occur duration of pump-and-treat cannot be determined.	Same as Alternative 3.	Need additional information to determine.	Will achieve RAO for preventing exposure to site groundwater within 1 year (by institutional controls). Will not achieve RAO of preventing migration of contaminated groundwater as only a portion of the on-site dissolved plume will be captured for treatment (residual zone). Need to quantity source mass to determine duration of treatment.	Addresses only a portion of the valley plume (1,000+ppb TCE); does not address migration of site plume or source removal.	Same as Alternative 7.	Same as Alternative 3.

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FEASIBILITY STUDY
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IMPLEMENTABILITY									
Ability to Construct and Operate	No construction or operation involved.	Same as Alternative 1.	Common well installation/construction techniques and equipment used for installation of extraction/containment system. Modular treatment system would be easily constructed. Recharge system installation/operation may be difficult due to site topography, land access and geology.	Common well installation/construction techniques and equipment of extraction/containment system. Modular treatment system would be easily constructed. Installation and construction of off-site treated water discharge line will require access to private properties.	More difficult to construct and operate than Alternative 6; large number of wells required to inject treatment materials.	Common construction techniques/ equipment used for installation of extraction/contain-ment system. Modular treatment system would be easily constructed. Recharge system installation may be difficult operation due to site topography, land access and geology.	Common construction techniques and equipment used for installation of extraction/containment system. Modular treatment system would be easily constructed. Installation and construction of treatment system and discharge line will require access to private properties.	More difficult to construct and operate than Alternative 7, large number of wells required for injection of treatment materials. Installation and construction of treatment system will require access to private properties.	Same as Alternative 4 and 7.

TABLE ES-1

TABLE E

COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES

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IMPLEMENTABILITY (continued)									
Ability to Obtain Approvals and Coordinate with Other Agencies	Coordination for 5-year reviews required and would be obtainable.	Same as Alternative 1 Deed restrictions may be difficult to implement and enforce.	Coordination may be required between state and local agencies for pumping and treatment system installation and operation. Groundwater withdrawal permit may be required. Coordination for long-term monitoring and 5-year reviews would be required. Deed restrictions and/or access agreements may be difficult to obtain.	Same as Alternative 3. Permit for stream discharge will be required.	Coordination required between state and local agencies for treatment system installation and operation. Coordination for long-term monitoring and 5-year reviews would be required. Deed restrictions may be difficult to implement.	Same as Alternative 3.	Same as Alternative 3. Permit for stream discharge will be required.	Same as Alternative 5.	Same as Alternatives 4 and 7.
Availability of TSD Services *and* Capacities	None required.	None required.	Disposal capacity for spent carbon *would be required.* Used carbon would probably be regenerated and reused.	Same as Alternative 3.	Implementation should generate *little RCRA waste.*	Same as Alternative 3.	Same as Alternative 3.	Same as Alternative 5.	Same as Alternative 3.

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IMPLEMENTABILITY (continued)									
Availability of Equipment, Specialists, and Materials	Personnel and equipment available for implementation of long-term monitoring and 5-year reviews.	Same as Alternative 1.	Ample availability of companies with trained personnel, equipment and materials for installation and operation/ maintenance of groundwater extraction/ containment and treatment systems, long-term monitoring program and 5-year reviews.	Same as Alternative 3.	Limited number of equipment and materials vendors; application/ injection methods tend to be patented which limits availability.	Same as Alternative 3.	Same as Alternative 3.	Same as Alternative 5.	Same as Alternative 3.
Availability of Technology	None required.	Sampling and laboratory analyses are widely available technologies.	Groundwater extraction and air stripping/carbon polishing are widely used, conventional technologies available from a variety of companies.	Same as Alternative 3.	Limited availability as new technology for groundwater remediation. Application/ injection methods tend to be patented which limits availability.	Same as Alternative 3.	Same as Alternative 3.	Same as Alternative 5.	Same as Alternative 3.

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COST									
Capital Cost ($)	$0	$16,074	$6,704,932	$6,339,215	$7,593,660	$3,607,300	$5,366,997	$8,012,805	$10,250,770
First Year Annual O&M Cost ($)	$0	$21,900	$2,258,976	$2,256,429	$21,900	$1,164,872	$223,120	$1,437,500	$2,256,429
Present Worth Cost ($)	$0	$581,148	$14,609,180	$14,211,857	$8,212,634	$8,649,466	$8,627,074	$26,469,716	$20,818,415

AR300031

1.0 INTRODUCTION

1.1 PURPOSE OF THE REPORT

This report presents the feasibility study (FS) prepared for the Crossley Farm Site, located in Hereford Township, Berks County, Pennsylvania. This FS report was prepared by Tetra Tech NUS Incorporated (TtNUS) for the United States Environmental Protection Agency (EPA) under Work Assignment 009-RICO-03S2, Contract No. 68-S8-3003. The Crossley Farm Site was formally added to the National Priorities List (NPL) in October 1992. The FS report presents a range of remedial alternatives that address potential human health risks from exposure to groundwater that has been impacted by previous hazardous waste dumping activities conducted at the site.

This FS was prepared consistent with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) 40 CFR 300. The Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, October 1988) was also followed.

The remedial alternatives developed and presented in this document will be used by EPA to formulate a preferred remedy to address contaminated groundwater that is currently migrating from the site. This preferred remedy will be presented to the local community during a public meeting and through the news media, and will be subject to a 60-day public comment period. After the public comment period has concluded, the selected remedy(s) will be documented in an EPA Record of Decision.

1.2 BACKGROUND INFORMATION

1.2.1 Site Description and Setting

The Crossley Farm Site is located in the Huffs Church community of Hereford Township, Berks County, Pennsylvania. This location is approximately 50 miles northwest of Philadelphia and 21 miles northeast of Reading (Figure 1-1). The site is located along the southern side of Huffs Church Road, approximately 3 miles west-northwest of State Route 100 and northwest of the borough of Bally (Figure 1-2).

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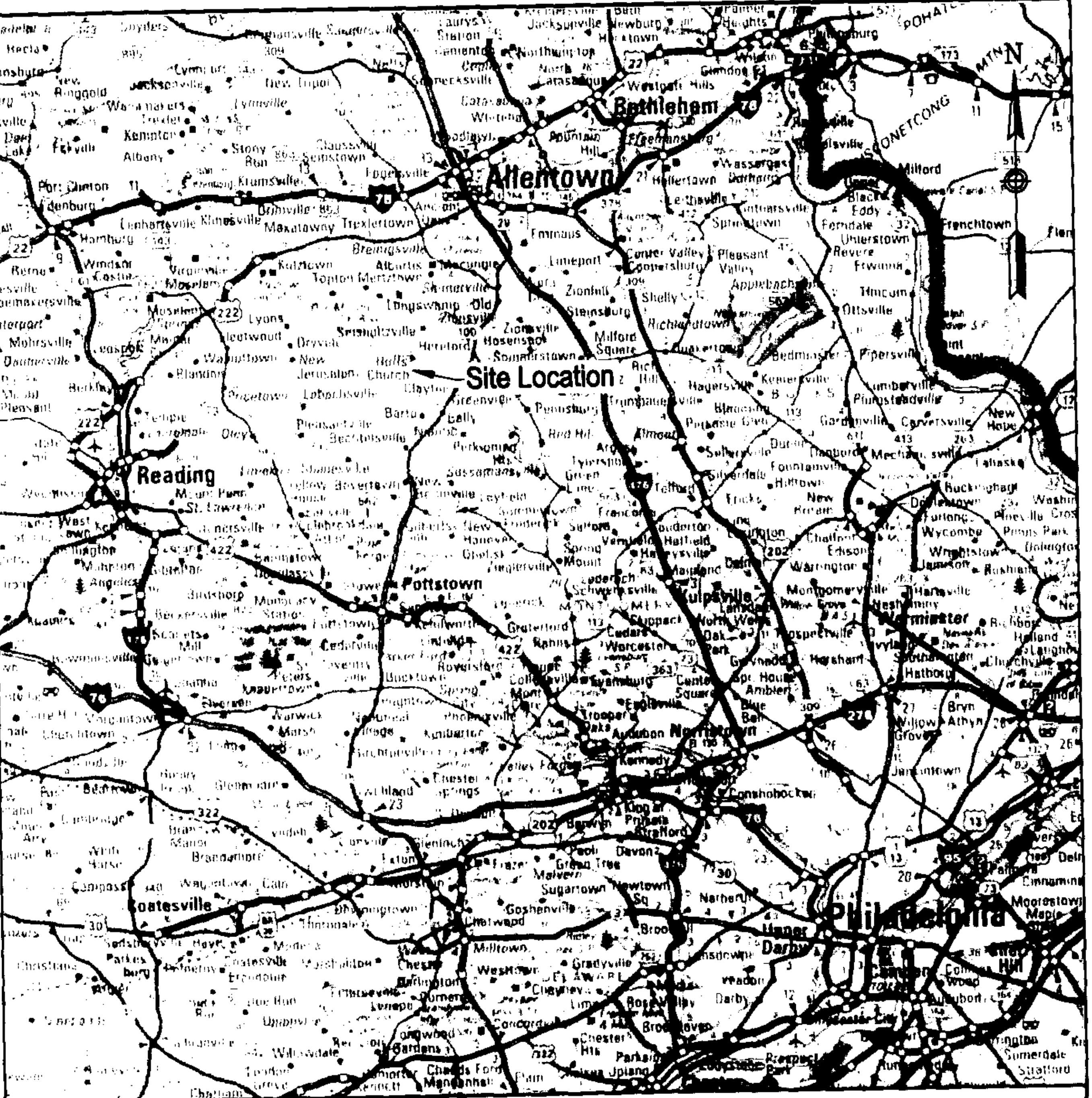

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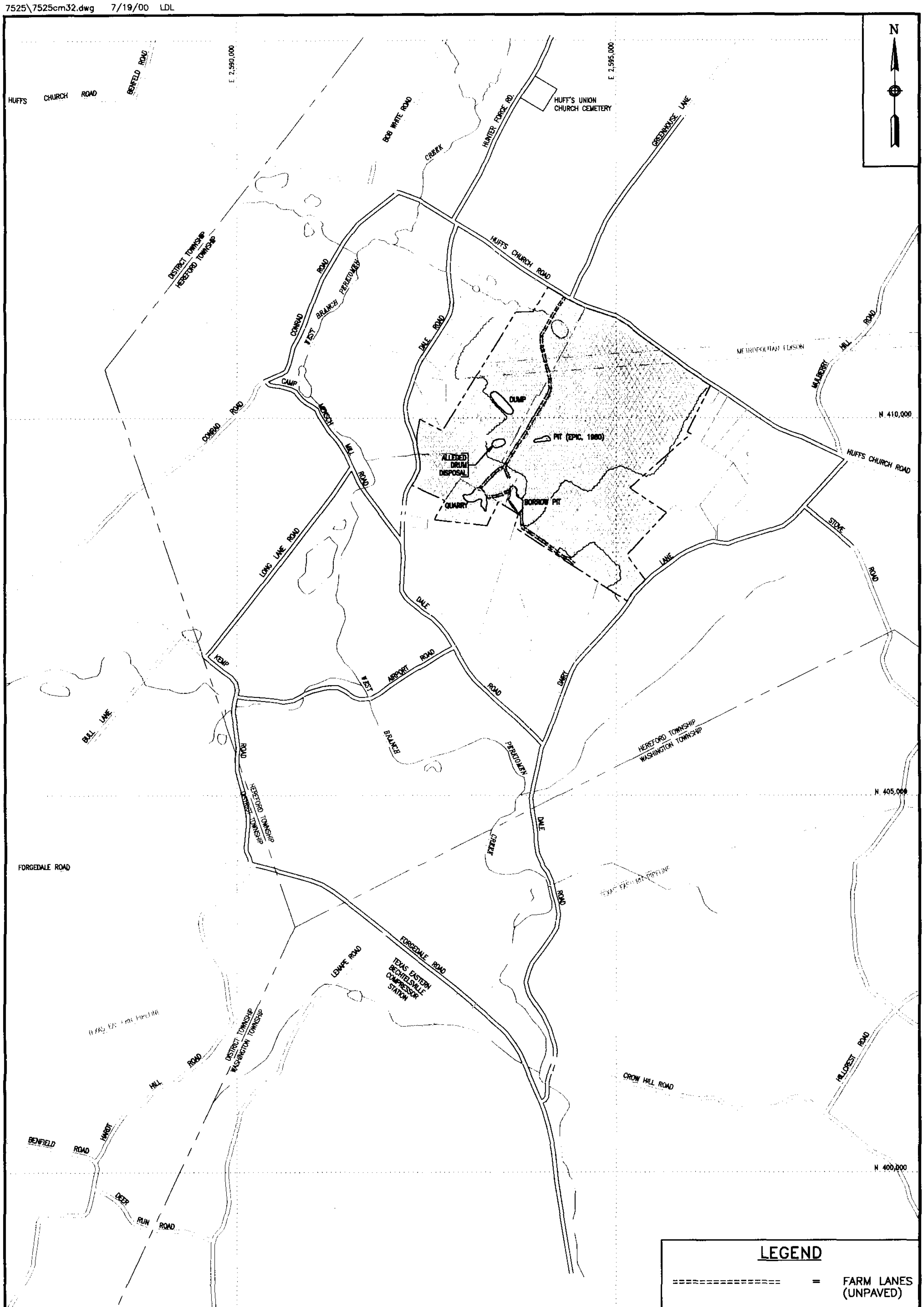

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The site is located within the Reading Prong Section of the New England Physiographic Province. The topography within the study area primarily reflects the complex underlying bedrock geology and consists of high hills and ridges underlain by more resistant metamorphic and igneous rocks and broad, low valleys underlain by less resistant carbonate rocks. The most prominent highland within the study area occurs at the site and is known locally as Blackhead Hill (Figure 1-3). The hill is very steeply sloped to the west and south of its crest. To the north and east of its crest, the hill is fairly level or flat and supports a working farm over much of its area. The crest of Blackhead Hill is underlain by the Hardystone Quartzite, which makes an attractive building stone. A small quarry at the crest of the hill has been active for over 50 years.

1.2.2 Site Operating History

As outlined in the January 2001 Remedial Investigation (RI) Report prepared by Tetra Tech NUS, Inc. (TtNUS, 2001) the Crossley Farm is an active farm that has historically operated as a dairy and crop farm. Some dairy farming still occurs, although the dairy operations were reportedly more extensive in the past; the dates of operation are uncertain. Presently most of the farm is devoted to the cultivation of feed crops, corn and alfalfa being the dominant ones.

The quarry at the crest of Blackhead Hill has been mined for building stone since at least 1946 (the date of the earliest aerial photograph available for the site). The presence of Hardystone Quartzite as building stone in older, local structures suggests that the quarry may have existed well before the 1940s. Site records indicate that a local building stone company routinely obtained stone from the quarry from 1957 to at least the late 1970s. The quarry is currently no longer in operation.

From the mid-1960s to the mid-1970s, a local plant reportedly sent numerous drums to the Crossley Farm for disposal. These drums contained mostly liquid waste and were described as having a distinctive 'solvent' order. The plant was believed to have used trichloroethene (TCE) as a degreaser from at least the mid-1960s until 1973. Tetrachloroethene (PCE) was supposedly used from at least the early 1960s until 1980.

Known and alleged waste disposal areas include a household dump, the quarry, a borrow pit, and a drum disposal area. Site features are depicted on Figure 1-4. The dump is located approximately 2,000 feet south of Huffs Church Road and reportedly consists chiefly of household trash. During the RI, groundwater monitoring was conducted in the vicinity of the dump and a number of test pits were excavated within the dump perimeter. The results from

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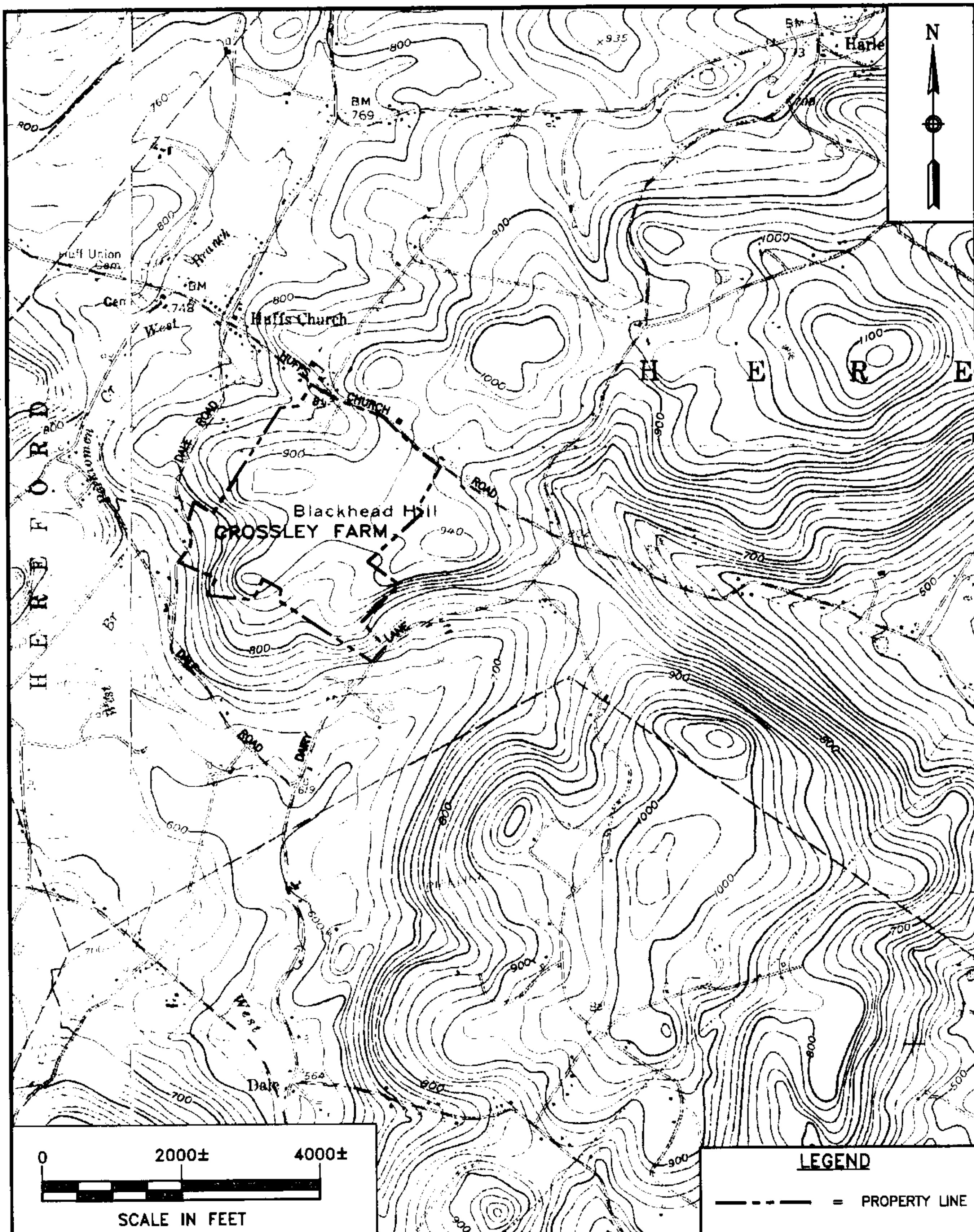

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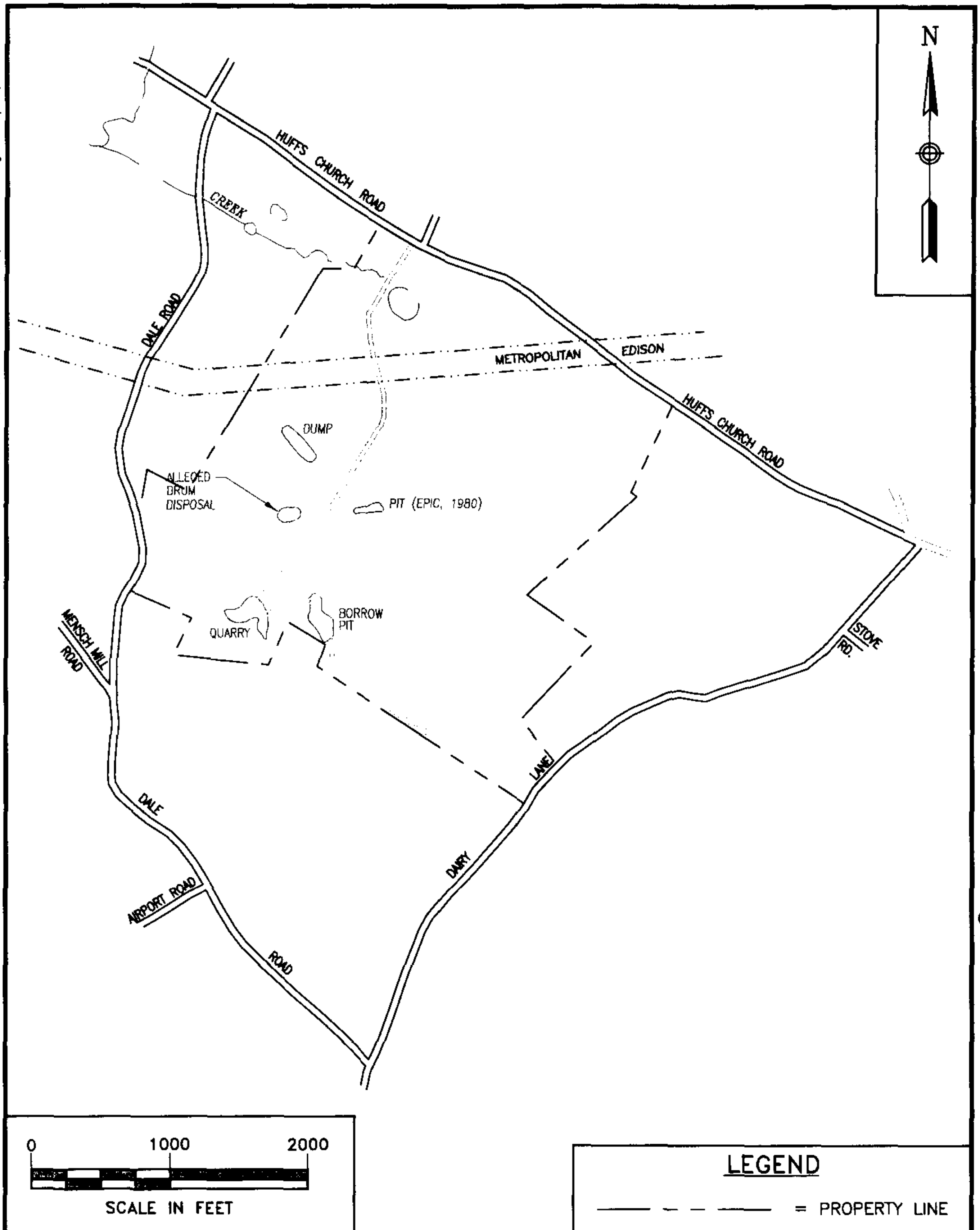

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REVISED BY	DATE		HEREFORD TOWNSHIP, BERKS COUNTY, PA	APPROVED BY	DATE
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these investigations support the visual evidence of household and miscellaneous trash disposal. The quarry is located approximately 3,000 feet south of Huffs Church Road and is allegedly a former site of unregulated disposal of hazardous waste, chiefly chlorinated solvents. However, the RI results indicate that the quarry area, if used for disposal purposes, is not a major contributor to the site groundwater contamination. The borrow area is located approximately 400 feet east of the quarry and is allegedly a former unregulated staging and/or disposal area of hazardous wastes, chiefly chlorinated solvents. Groundwater sampling and analysis conducted during the RI indicates that the borrow pit area is an area of residual groundwater contamination, specifically TCE and PCE. The borrow pit was most likely used as a source of overburden soil during the quarry operations. Little, if any overburden material remains within the current pit area; instead the exposed material consists of dense, weathered saprolite or bedrock material with little vegetation. Concentrations of TCE are greatest at depth and in the direction of the bedrock gradient immediately beneath the borrow pit area. The drum disposal area was identified during the RI based on the geophysical surveys conducted at the site and confirmation test pits conducted in December 1997. During the summer of 1998, EPA initiated an Emergency Removal Action and subsequently excavated and removed approximately 1,200 buried drums and drum remains and 15,000 tons of contaminated soil.

1.2.3 Regulatory History

Regulatory involvement at this site began in 1983, when local residents complained to the Pennsylvania Department of Environmental Protection (PADEP) about odors in their private water supply wells. A PADEP sampling program of local wells conducted in September 1983 revealed concentrations of TCE as high as 8,500 ug/l and PCE as high as 110 ug/l. A subsequent sampling round conducted by PADEP and the EPA Region III Technical Assistance Team (TAT) contractor in November 1983 revealed that eight home wells contained detectable levels of TCE, and in six of these wells the concentrations of TCE exceeded 200 ug/l.

As a result of the November 1983 sampling, PADEP issued a health advisory on groundwater use in the area and recommended either boiling water, installing carbon filtration systems, or using bottled water where TCE concentrations exceeded 45 ug/l. Shortly thereafter, a temporary water supply was provided by the Pennsylvania National Guard through the Pennsylvania Emergency Management Agency. This supply was terminated in mid-1985.

After the health advisory was issued, local residents began to voice concerns about Crossley Farm and the alleged dumping of wastes there. In response to these concerns, EPA directed the Region III Field Investigation Team (FIT) contractor to conduct a preliminary assessment of the property. The PA, completed in June 1984, concluded that insufficient information existed to identify the source of the groundwater contamination and suggested that a regional groundwater study be conducted.

Further citizen complaints in August 1986 prompted additional rounds of sampling by the TAT contractor in September 1986. TCE levels detected during these rounds ranged up to 19,000 ug/l. In October 1986, the Agency for Toxic Substances and Disease Registry (ATSDR) performed a health consultation for EPA. Additional well sampling in November 1986 detected TCE at a maximum level of 22,857 ug/l. EPA initiated a removal action in December 1986 and in, January 1987, EPA began installing carbon filtration units on impacted private wells.

In the Spring of 1987, EPA directed the Region III Emergency Response Team (ERT) contractor to conduct a regional hydrogeological investigation to include the installation and sampling of on- and off-site monitoring wells and the sampling of residential well supplies. This investigation, completed in August 1988, concluded that the source of the TCE in the groundwater was near the crest of Blackhead Hill. The abandoned quarry and the borrow pit area were cited as the presumed source areas. The investigation delineated a contaminated groundwater plume extending approximately 7,000 feet downgradient from Blackhead Hill and along Dale Road.

Concurrent with and independent of the EPA study, residential wells near Dale Road were sampled and analyzed for polychlorinated biphenyls (PCBs) and other contaminants as part of a PADEP investigation of the Texas Eastern – Bechtelsville compressor station. One residential well located on Forgedale Road contained TCE at levels greater than 200 ug/l, suggesting that the TCE plume associated with the Crossley Farm Site extended even farther to the south than mapped, since TCE was determined not to be a common waste product from compressor station operations. This result prompted additional sampling by EPA along Forgedale Road, south to Old Route 100, as part of the Crossley Farm investigation. These analytical data indicated that the plume extended south of the compressor station and Forgedale Road and about 9,000 feet downgradient from Blackhead Hill.

In February 1991, EPA issued the Hazard Ranking System (HRS) package for the Crossley Farm Site in preparation for the site's proposed listing on the National Priorities List (NPL). In July 1991, the site was proposed for the NPL. The site was formally listed on the NPL in October 1992.

In September 1991, ATSDR performed a health consultation of the Crossley Farm Site at the request of the Pennsylvania Department of Health (PADOH). ATSDR recommended that the full extent of the contaminated groundwater plume be defined and that all supply wells that could potentially be affected by the contamination be identified and monitored.

In March 1992, PADOH and ATSDR held a community meeting to meet with interested or concerned residents. ATSDR representatives discussed the National Exposure Registry and the process of bringing exposed individuals into the TCE Subregistry. In the days following the meeting, some area residents believed to have been exposed to the highest levels of TCE in the groundwater were added to the registry. PADOH and ATSDR also conducted a presentation to the Berks County Medical Society on the TCE contamination of environmental media at several NPL sites in Berks County and the toxic effects of TCE on humans.

In February 1993, ATSDR finalized a preliminary public health assessment for the Crossley Farm Site. The assessment concluded that the site presented an urgent public health hazard and made recommendations to reduce the public health risk associated with the site.

In July 1994, ATSDR issued a Site Review and Update (SRU) for the Crossley Farm Site. The SRU stated that the site remained a public health hazard to area residents and recommended that either a health consult or another SRU be performed upon completion of a planned remedial investigation for the site.

In September 1994, EPA tasked Halliburton NUS Corporation (HNUS) to perform a remedial investigation and feasibility study (RI/FS) for the site. It was decided during subsequent scoping meetings and discussions that the investigation and ultimate disposition of the contaminated residential well supply problem should be expedited and addressed in a focused feasibility study (FFS) prior to the site investigation activities.

The RI field activities began in October 1996 with the execution of surface geophysics and soil gas surveys. These surveys identified an extensive geophysical anomaly indicative of subsurface metallic materials with associated elevated soil gas detections for chlorinated solvents in the agricultural field northeast of the quarry and borrow pit areas. The anomaly was in an area of historically disturbed soils identified in an analysis of historical aerial photographs. A test pit excavated in December 1997 by the EPA Removal Section confirmed the presence of buried drums and associated contaminated soil. The subsequent removal action conducted during the summer of 1998 resulted in the excavation and removal of approximately 1,200 buried drums and 15,000 tons of contaminated soil.

To support the FFS, for the contaminated residential well supply problem a preliminary risk assessment (PRA) using the limited historical residential analytical data was completed by HNUS in October 1996 to support the FFS and to identify contaminants of concern, potential exposure pathways that could result in unacceptable risks to residents living near the site, and residences that may be subjected to potential health risks from using groundwater affected by site contaminants (HNUS, 1996). The PRA determined that TCE was the major contributor of carcinogenic risk for most of the affected wells, although other Chemicals of Concern (COCs) (principally chlorinated solvents) also individually contributed carcinogenic risk in excess of 1E-6. Similarly, TCE was the major contributor to noncarcinogenic risk, with an individual Hazard Quotient (HQ) exceeding 1.0.

The FFS for residential water supplies was completed in January 1997 (HNUS, 1997). The FFS presented a detailed analysis of four potential remedial alternatives, including no action, delivered water, point-of-entry treatment, and a water line. For the Proposed Plan, EPA selected the point-of-entry treatment system (carbon filtration units) as its preferred alternative. The FFS and the Proposed Plan were released to the public on February 10, 1997, and the public comment period extended from February 10 to March 12, 1997. A public meeting was held in the vicinity of the site at the Washington Township Elementary School on March 5, 1997.

On June 30, 1997, the Record of Decision (ROD) for OU-1 was signed by EPA (EPA, 1997). The ROD presented the factual and legal basis for EPA's selection of the point-of-entry treatment system as the interim remedy for contaminated potable sources at the site and their decision to install the systems on all residential supplies that had been impacted by the site. In September 1997, EPA tasked Brown and Root Environmental (now part of Tetra Tech NUS) to perform the remedial design (RD) for the point-of-entry treatment systems.

1.3 SITE GEOLOGY, HYDROGEOLOGY AND HYDROLOGY

1.3.1 Site Geology

The Crossley Farm Site lies within the Reading Prong Section of the New England Physiographic Province. The Reading Prong is a large northeast-southwest trending highland of Precambrian age crystalline rocks and Paleozoic age sedimentary rocks that are bordered to the north and west by Lower Paleozoic carbonate rocks and shales of the Great Valley Physiographic Province and to the south and east by shales, sandstones, and conglomerates of the Triassic Lowlands. The project area is underlain by the Precambrian Age crystalline rocks of the Byram Intrusive Suite, the Cambrian Age sandstones and conglomerates of the

Hardystone Formation, and the Cambrian to Ordovician age limestones and dolomites of the Leithsville Formation. Further detailed information regarding the site geology is presented in the RI Report.

Several surface quarries and ore pits exist either on the Crossley Farm property or within the study area. A small circular-shaped pit located immediately south and downslope of the Trash Dump has been referred to as the Mica Mine by local residents. The actual dates and extent of prospecting or mining that took place at this location are unknown; the pit is currently eroded and overgrown.

1.3.2 Site Hydrogeology

The results of the RI indicate that groundwater within the study area occurs within a complex, two-component hydrogeologic system. The upper component (upper flow zone) of the groundwater flow system consists of the soil and saprolite. The lower component (lower flow zone) of the groundwater flow system consists of the less-fractured, fresh bedrock that occurs below the saprolite.

Groundwater within the upper flow zone flows within the granular weathered material and the relict structure (fractures, cleavage planes, bedding planes) of the soil and saprolite. The physical properties of the saprolite (e.g., thickness, porosity, permeability) are the dominant factors controlling the occurrence and migration of the groundwater within this zone.

The groundwater within the bedrock is encountered within and is restricted to the secondary openings (discrete fractures) within the rock mass and, to a very limited degree, to the intergranular openings of the relict soil or faulted shear zones encountered in several boreholes. The interconnected networks of fractures within the bedrock serve as the primary groundwater migration pathways.

Water-bearing fractures of varying yields were encountered at significant depths within the deepest boreholes drilled at each monitoring location, with the exception of the boreholes drilled along the Trash Dump Ridge and possibly within the quartzite found downgradient within the Dale Valley. As noted in the RI, this is significant because it indicates that the base of the groundwater flow system has not been defined or identified.

1.3.2.1 Groundwater Flow Direction

Groundwater in the study area flows in response to the three-dimensional, subsurface distribution of hydraulic head. The horizontal and vertical flow directions are variable and are controlled by topography, bedrock structure, and the locations of groundwater recharge and discharge points. In general, the groundwater flows from the recharge areas in the topographic highs to the discharge areas in the topographic lows.

Groundwater-elevation contour maps were constructed using a synoptic round of hydraulic head elevations measured on July 1, 1999. Maps were generated for the shallow, intermediate and deep groundwater zones in the vicinity of the site (i.e., Blackhead Hill) and immediately downgradient in the adjacent valley. Figure 1-5 details groundwater flow within the shallow zone, Figure 1-6 the intermediate zone and Figure 1-7 the deep zone.

Due to a low density of well numbers within the Dale Valley, groundwater flow maps were not prepared. Based on the available RI data, the groundwater flow directions within all three zones in the valley mimic the surface topography. Detailed information on the groundwater elevation sampling and interpretation of results is presented in the RI Report.

1.3.3 Surface Water Hydrology

The Crossley Farm site occupies a local topographic high that is bisected by several secondary ridges, resulting in multiple surface water drainage pathways and directions. The majority of surface water from the site flows into the West Branch Perkiomen Creek. Drainage from the extreme northeastern corner of the site flows into the Main Branch Perkiomen Creek.

Several permanent and intermittent (temporary) surface water bodies occur on the Crossley Farm Site (see Figure 1-8). These include:

- A spring-fed stock pond that is located immediately south of Huffs Church Road. Water from the pond exists the site via a perennial stream that is an unnamed tributary to the West Branch Perkiomen Creek.

- A small perennial stream that begins at the emanation point of on-site Spring No. 101, located along the western flank of Blackhead Hill. The stream is intermittent above of the

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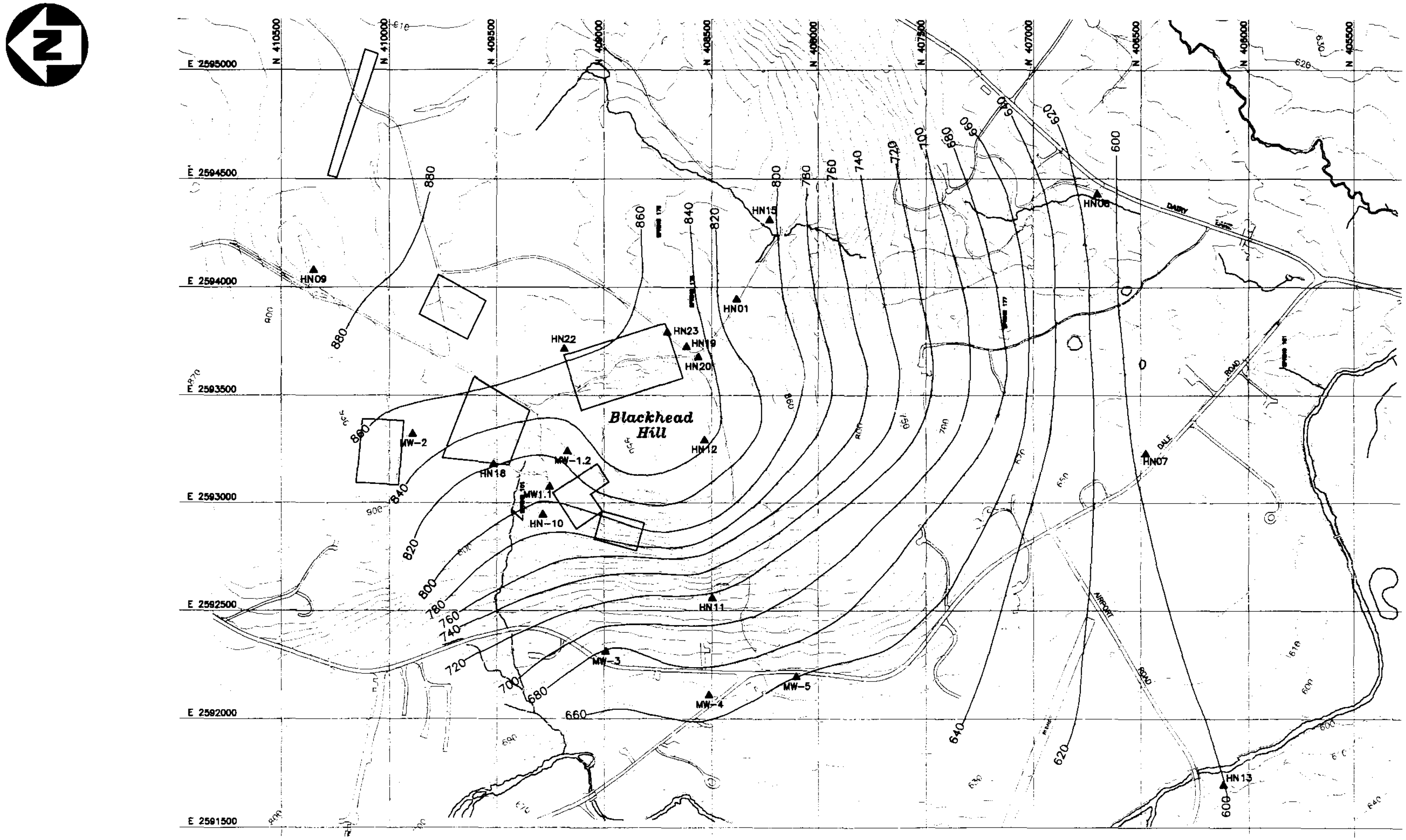

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REVISED BY / DATE	JULY 1, 1999	APPROVED BY	DATE
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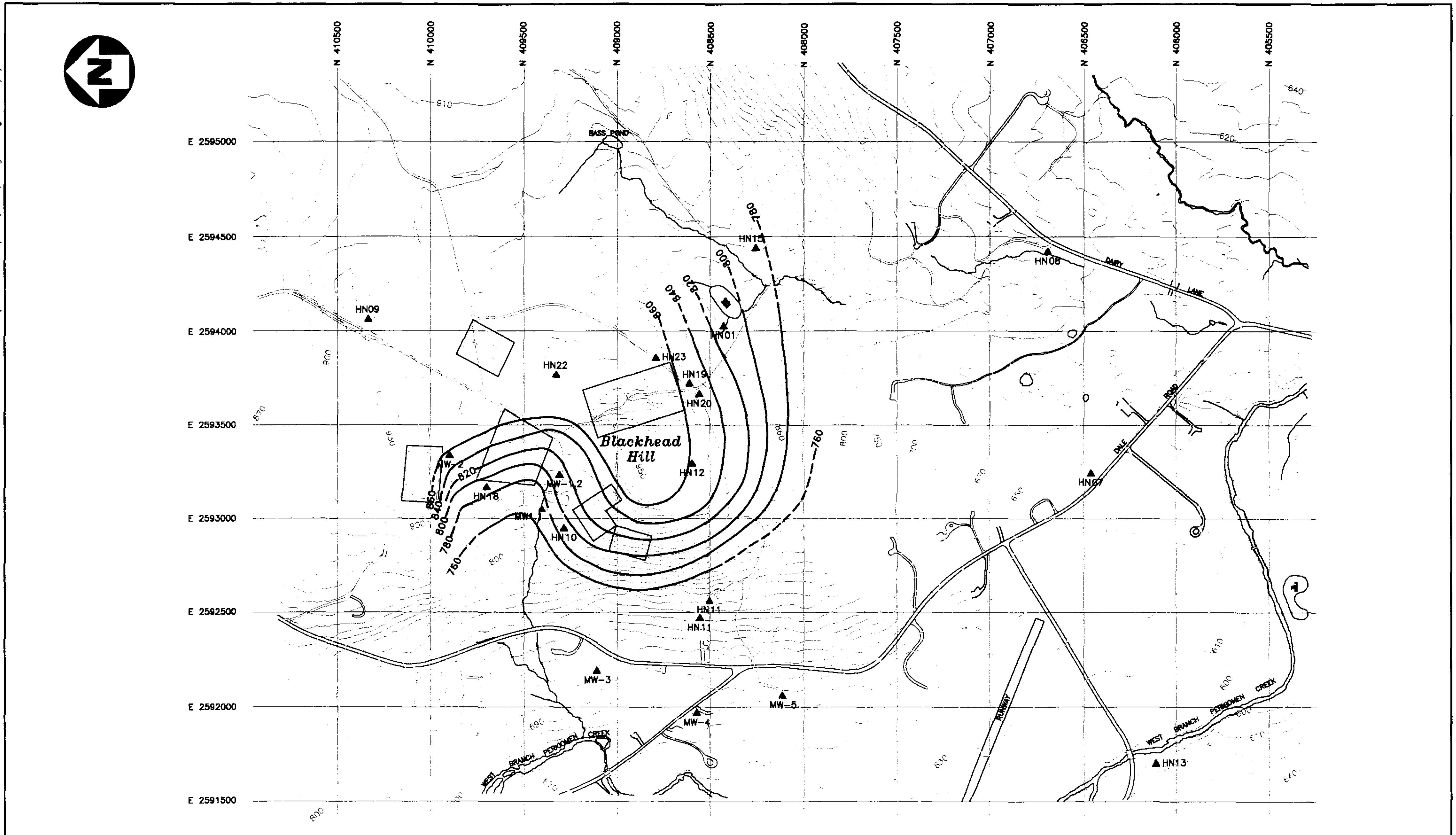

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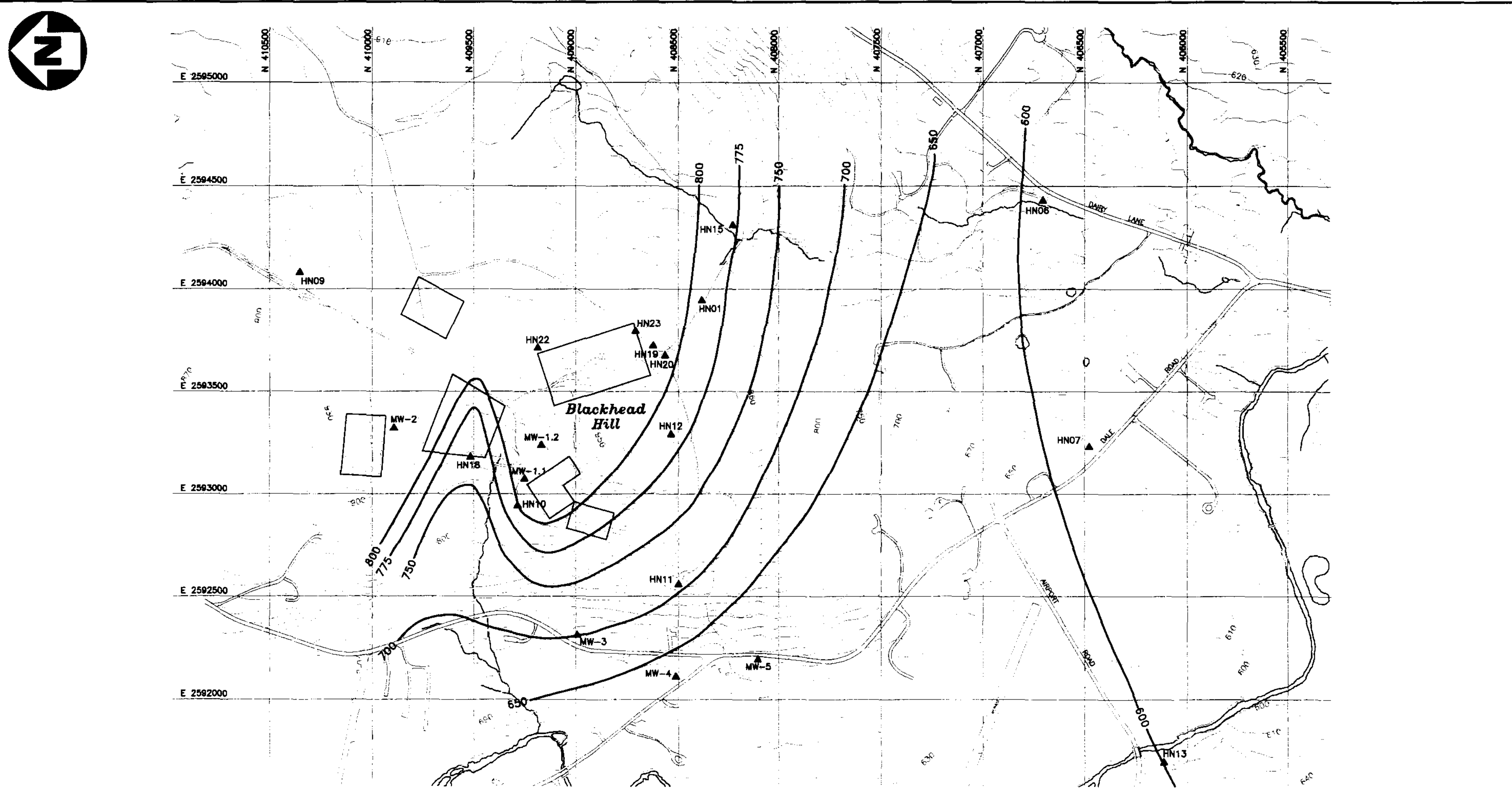

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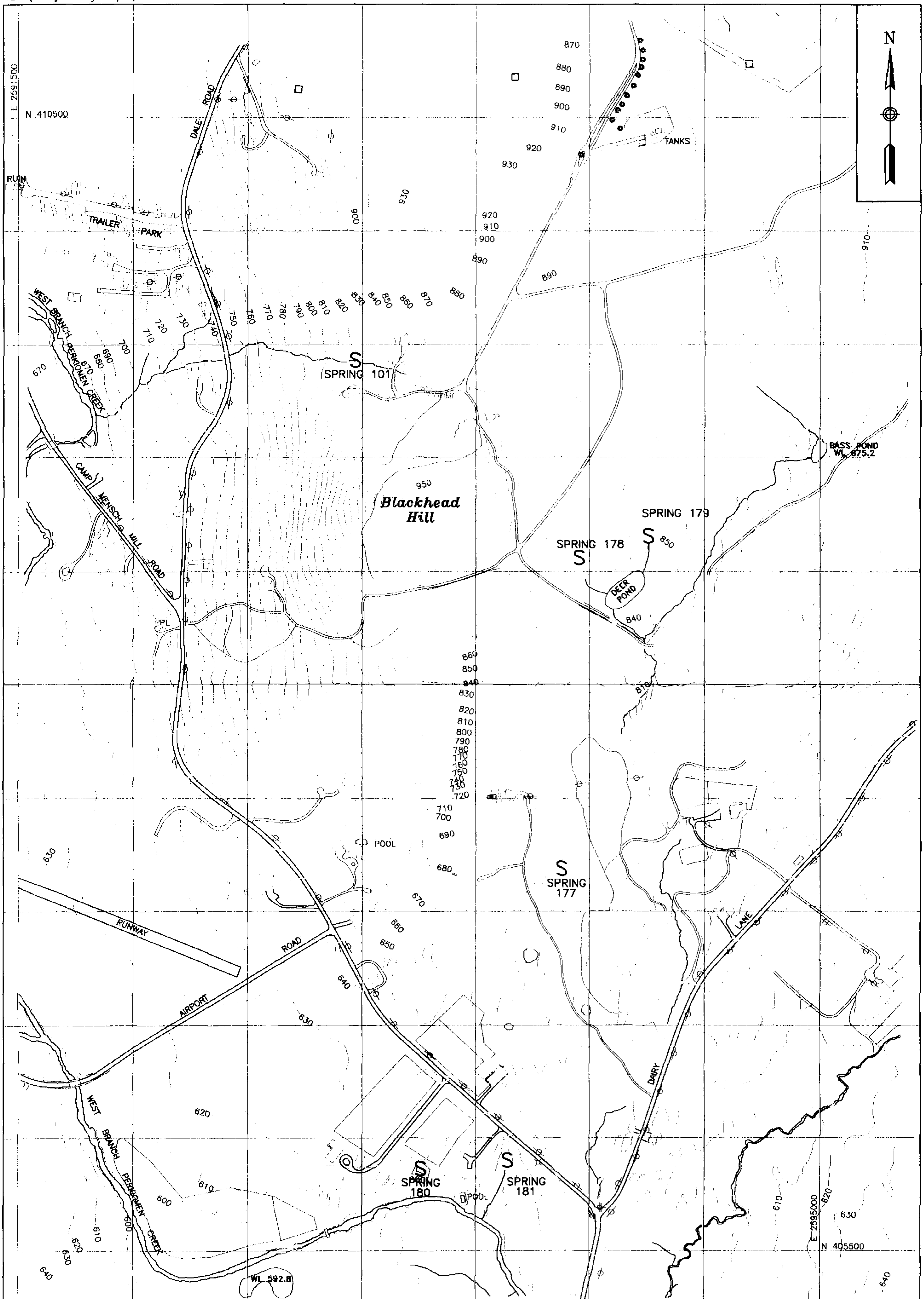

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spring and basically channels stormwater runoff from a large portion of the agricultural fields. The emanation point of the spring migrates up and down the slope of the hill, depending on the season and the position of the water table.

- A temporary or seasonal pond occurs within the woods to the south and southeast of the borrow pit and the agricultural fields. The pond (i.e., Deer Pond) is fed by two intermittent springs, No. 178 and No. 179, that emanate immediately south of the tree line and in the break of slope separating the agricultural fields from the woods. Spring No. 178 emanates from a PVC pipe that sticks out from the slope break. The source of the water flowing from the pipe is unknown. The RI states that, "the pipe may merely improve the spring by collecting and channeling the water, or the pipe may represent the discharge point for a tile field installed beneath the upgradient agricultural fields."

- A pond, known as the Bass Pond, occurs within the woods adjacent to the southeastern border of the site. This pond is fed by an intermittent stream that channels surface water from the agricultural fields in that portion of the site. It is likely that the pond is also fed by a spring(s), since during the RI it always appeared to have water, regardless of the frequency or amount of precipitation.

Based on the RI, it appears that most of the surface water drainage from the site flows into the West Branch Perkiomen Creek. The drainage from the extreme northeastern corner of the site flows into the Main Branch Perkiomen Creek.

1.4 NATURE AND EXTENT OF CONTAMINATION

1.4.1 <u>Groundwater</u>

As outlined in the RI Report (TtNUS 2001) groundwater beneath the site may be classified into three zones – shallow, intermediate, and deep. Analytical data collected from several sources, including monitoring wells, residential wells, and potable and non-potable springs were used to determine the nature and extent of contamination. Groundwater samples were analyzed for TCL VOCs, TCL SVOCs, TCL pesticides/PCBs, TAL metals, and miscellaneous parameters.

1.4.1.1 Volatile Organic Compounds

The primary contaminants that were detected in groundwater at levels exceeding their respective MCLs were chlorinated VOCs. TCE was the most common and dominant groundwater contaminant; to such an extent that the extent of the plume can largely be defined on the occurrence of TCE. PCE and cis-1,2-dichloroethene (Cis-1,2–DCE) were also detected on a routine basis at elevated concentrations.

TCE was commonly detected in samples taken from monitoring wells, residential wells, and potable and non-potable springs. TCE was detected in 56 of 79 monitoring well samples at concentrations ranging as high as 190,000 ug/l in the vicinity of the borrow pit (at HN-23I), in 70 of 309 residential well samples at concentrations ranging as high as 3,800 ug/L west of the site along Dale Road (at RW-99), and in spring samples at concentrations ranging as high as 3,000 ug/l immediately downgradient from the EPIC pit area at SW-11 (Spring No. 101). The MCL for TCE for protection of human health is 5.0 ug/L. Figure 1-9 details the distribution of TCE in shallow groundwater in the immediate vicinity of the site. As shown, the highest concentrations of TCE are immediately downgradient of the borrow pit (HN-20S at 7,500 ug/L) and in the numerous shallow groundwater monitoring points located within the topographic saddle between the quarry area and the trash dump area (including HN-10S at 1,200 ug/L, HN-18S at 2,300 ug/L, MW 1.10B at 4,300 ug/L, MW1.20B at 1,800 ug/L, and Spring No. 101 at 3,000 ug/L). The areal distribution of TCE and the directions of groundwater flow indicate that the borrow pit area and the EPIC pit area (i.e., drum excavation area) are source areas for TCE in shallow groundwater.

Figure 1-10 details the total extent of the TCE plume within the shallow groundwater zone throughout the study area. The two most notable features concerning the TCE plume within the study area are the discontinuous nature of the plume near the base of Blackhead Hill and the total length of the plume (approximately two miles). Detailed information on the distribution and concentration of TCE is outlined in Section 4.0 of the RI Report.

The distribution of TCE in the intermediate groundwater zone at the site is detailed in Figure 1-11. The map shows that within this zone, the plume of groundwater contaminated to concentrations exceeding 1,000 ug/l has grown in areal extent relative to the extent of the shallow groundwater plume; the plume underlies a large portion of the site; and the plume extends downgradient and downhill into the Dale Valley. The total extent of the TCE plume within the intermediate groundwater zone throughout the study area is shown on Figure 1-12. The plume of TCE contaminated groundwater extends approximately 6,800 feet from the source area on Blackhead Hill and based on the available data appears to be continuous within the total extent of the plume.

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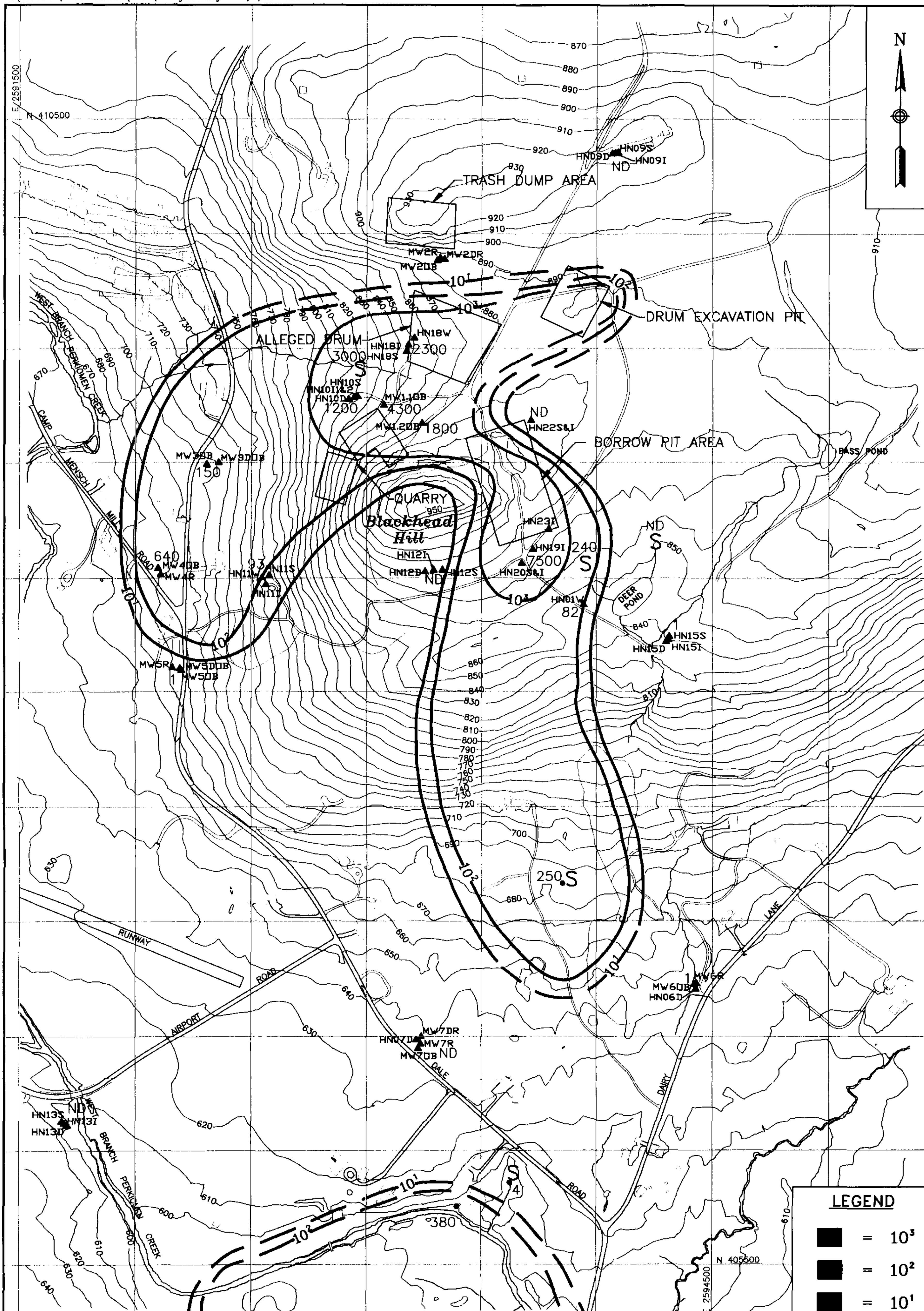

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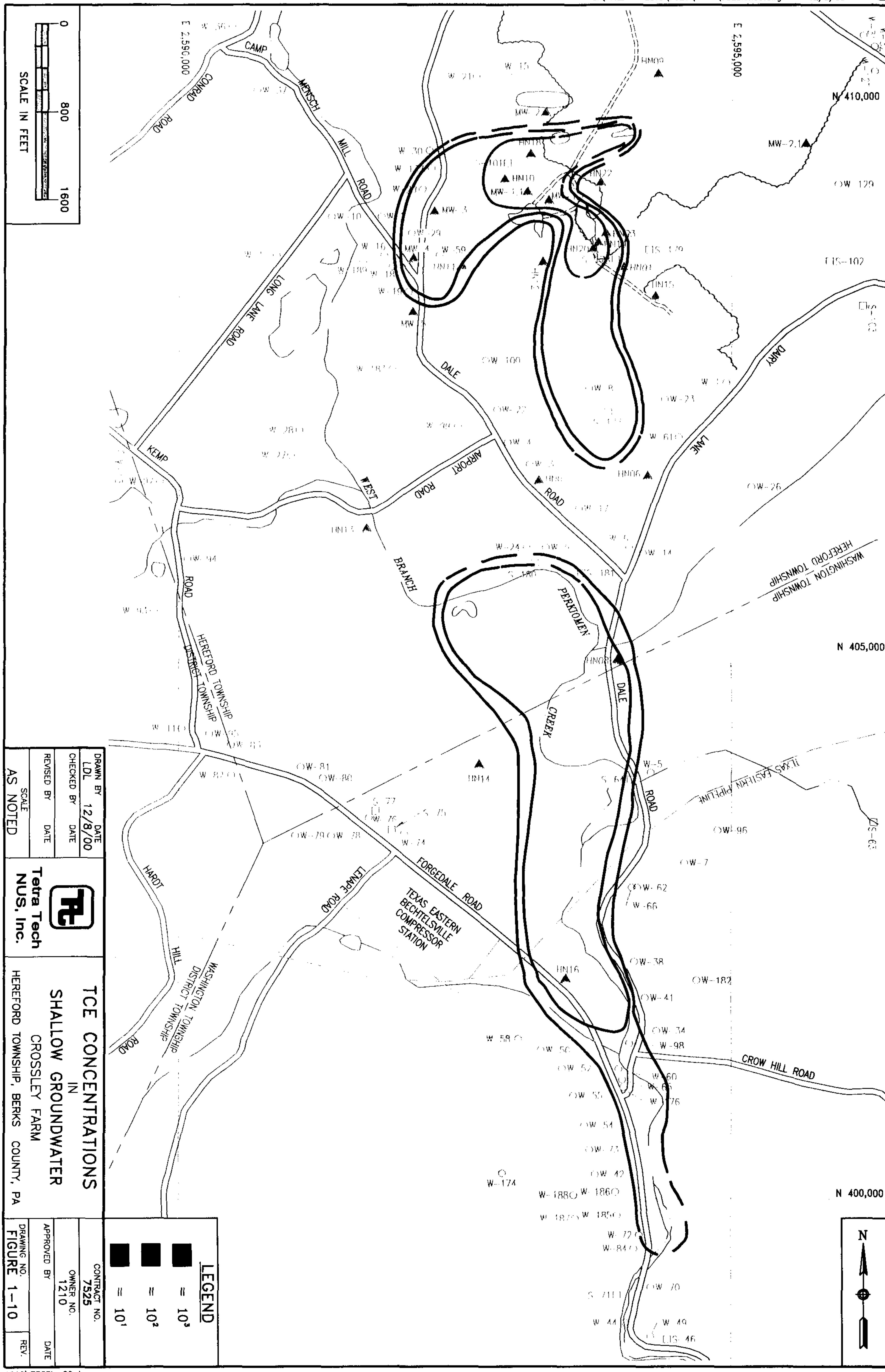

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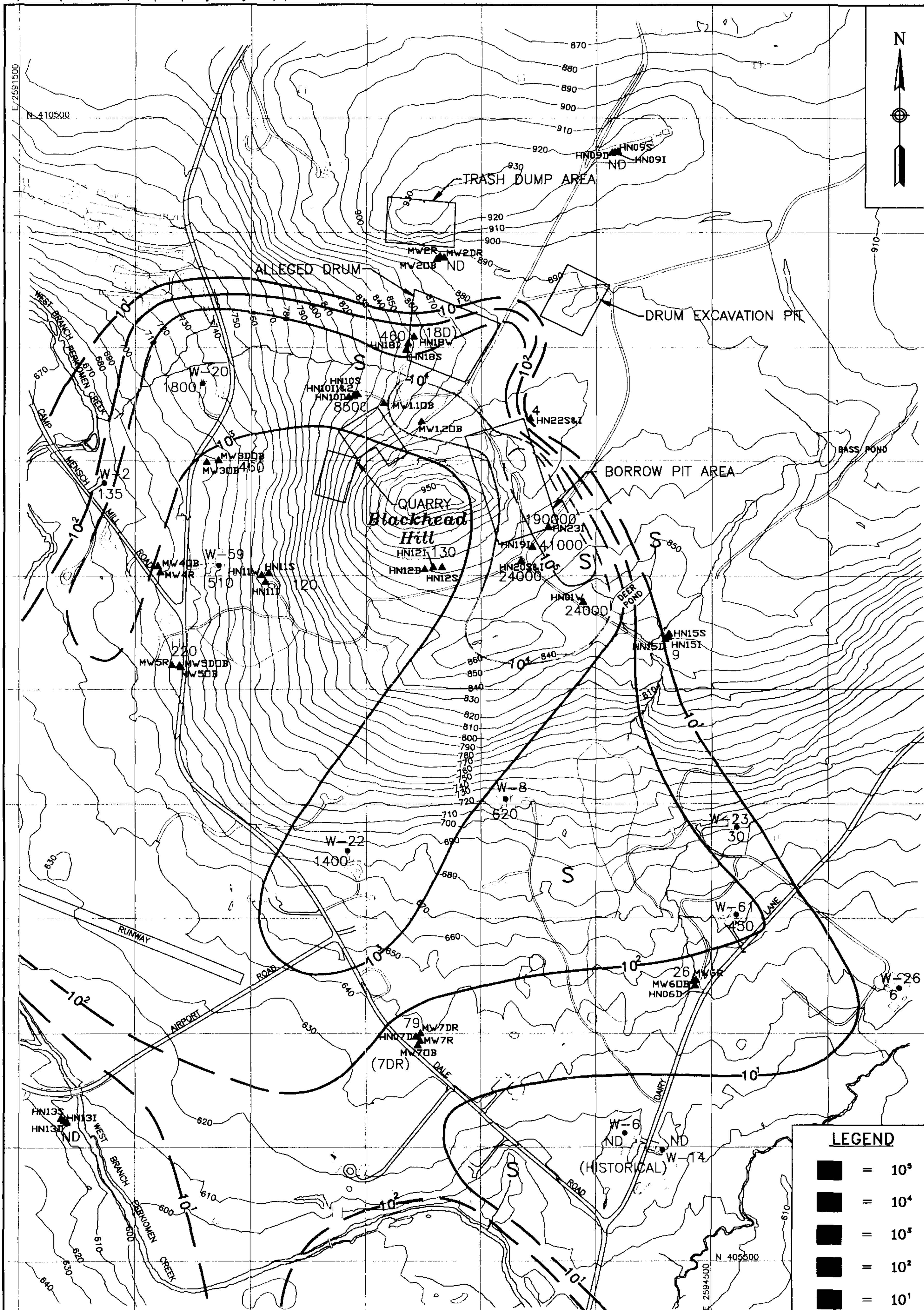

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TCE CONCENTRATIONS IN INTERMEDIATE GROUNDWATER

CROSSLEY FARM

HEREFORD TOWNSHIP, BERKS COUNTY, PA

CONTRACT NO.	7525
OWNER NO.	1210
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DRAWING NO. FIGURE 1-11	REV.

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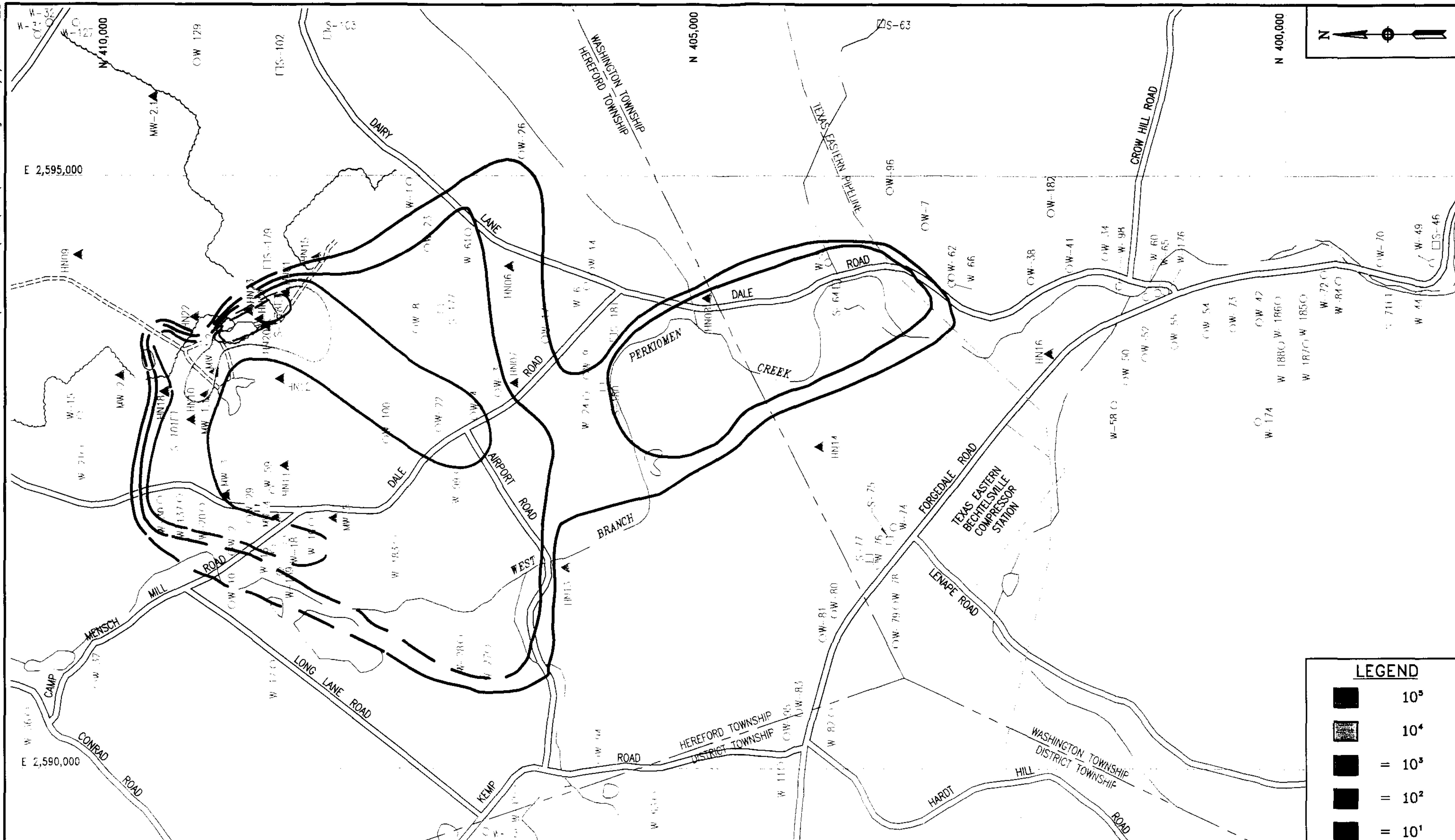

LEGEND

	10^5
	10^4
	$= 10^3$
	$= 10^2$
	$= 10^1$

DRAWN BY LDL	DATE 12/8/00		CONTRACT NO. 7525
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SCALE AS NOTED			DRAWING NO. FIGURE 1-12 / REV.

TCE CONCENTRATIONS IN INTERMEDIATE GROUNDWATER

CROSSLEY FARM

HEREFORD TOWNSHIP, BERKS COUNTY, PA

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Figure 1-13 details the distribution of TCE within the deep groundwater zone in the immediate vicinity of the site. The map shows that within the deep zone, the plume of groundwater contaminated to concentrations exceeding 1,000 ug/L has expanded in areal extent relative to the extent of the intermediate groundwater plume. Within the southern lobe of the deep groundwater plume, the extent and degree to which TCE has migrated into the fractured bedrock in the vicinity of and immediately downgradient of the borrow pit (near the HN-19, -20 and –23 well clusters) is not known, as there are no deep monitoring wells within this area. As detailed in the RI and based on the available analytical database, the total vertical extent of groundwater contamination near the source area is not known, as it was demonstrated that TCE concentrations consistently increase with depth to the total depths of the RI investigation. The total extent of the TCE plume within the deep groundwater zone throughout the study area is illustrated in Figure 1-14 and depicts a plume extending approximately 10,000 feet from the source areas on Blackhead Hill.

PCE and Cis-1,2-DCE were detected in samples collected during the RI from monitoring wells, residential wells, and potable and non-potable springs. As noted during the RI, the areal extent of PCE is similar to the extent of TCE, but at generally much lower concentrations. Within the shallow groundwater zone in the immediate vicinity of the site, the PCE areal distribution is similar to the distribution of TCE, that is, the highest concentrations of PCE are detected immediately downgradient of the borrow pit and in the topographic saddle between the quarry area and the trash dump area. The total extent of the PCE within the shallow groundwater zone throughout the study area is somewhat smaller than the total extent of TCE. The total length of the plume, as noted in the RI Report is approximately 8,000 feet.

The distribution of PCE within the intermediate groundwater zone in the immediate vicinity of the site, follows the bilobed pattern that is representative to the distribution of TCE. The highest concentrations of PCE within the southern lobe of the plume occur in the wells containing the highest concentrations of TCE, including HN-23 (6,000 ug/L), HN-19 (1,700 ug/L) and HN-20 (1,100 g/L).

Within the deep zone in the immediate vicinity of the site, the occurrence of PCE is similar in distribution to TCE. However, the extent and degree to which PCE has migrated into the fractured bedrock is not well defined within the southern lobe of the plume due to an insufficient number of monitoring wells. The total extent of the PCE plume within the deep groundwater zone throughout the study area is similar to the extent of TCE. The PCE plume is approximately 9,600 feet in length, and is defined at its downgradient extent by measured detections in monitoring well cluster HN-16 and residential wells W-58 and W-42.

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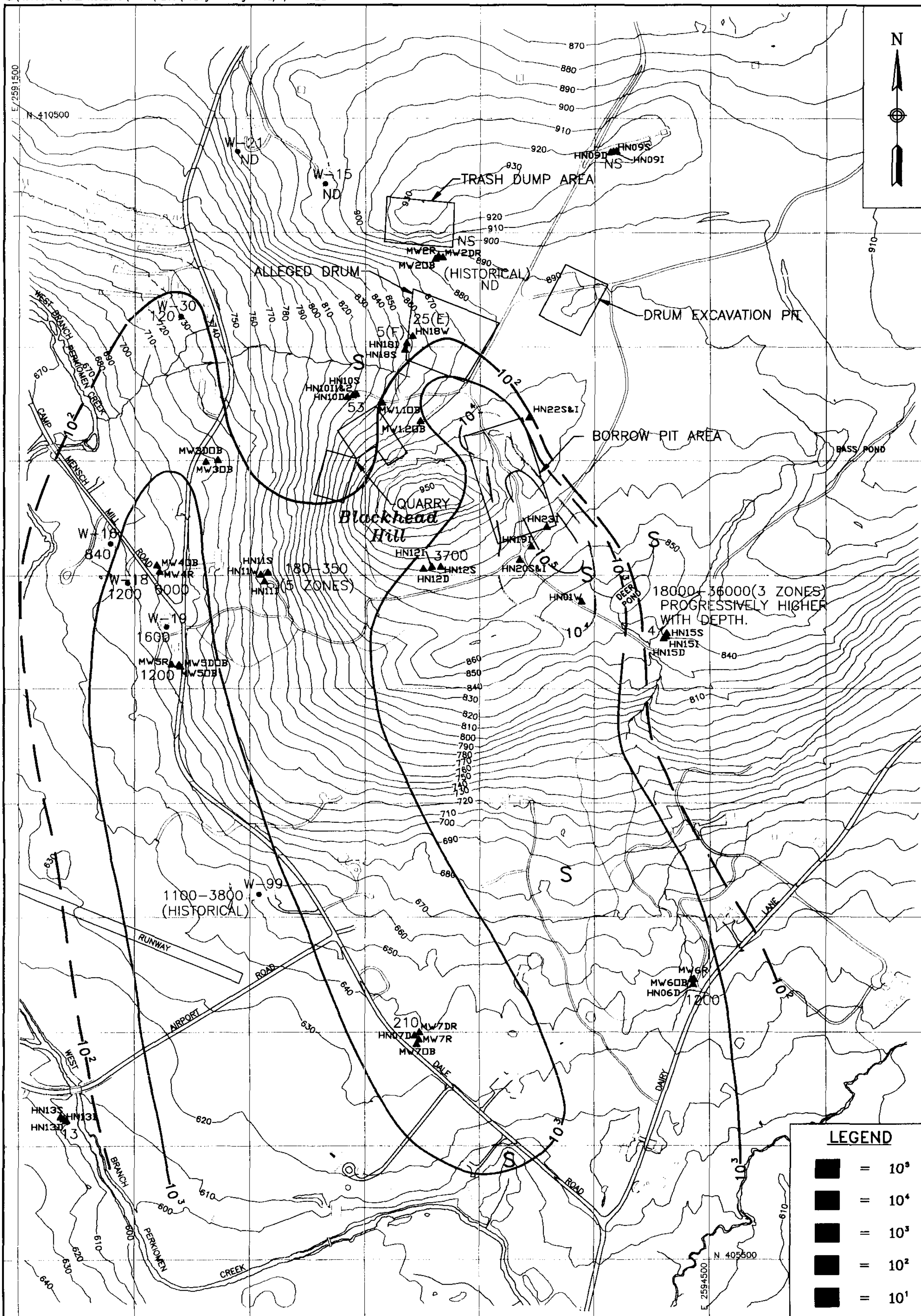

DRAWN BY LDL	DATE 12/8/00		TCE CONCENTRATIONS IN DEEP GROUNDWATER	CONTRACT NO. 7525
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REVISED BY	DATE		HEREFORD TOWNSHIP, BERKS COUNTY, PA	APPROVED BY / DATE
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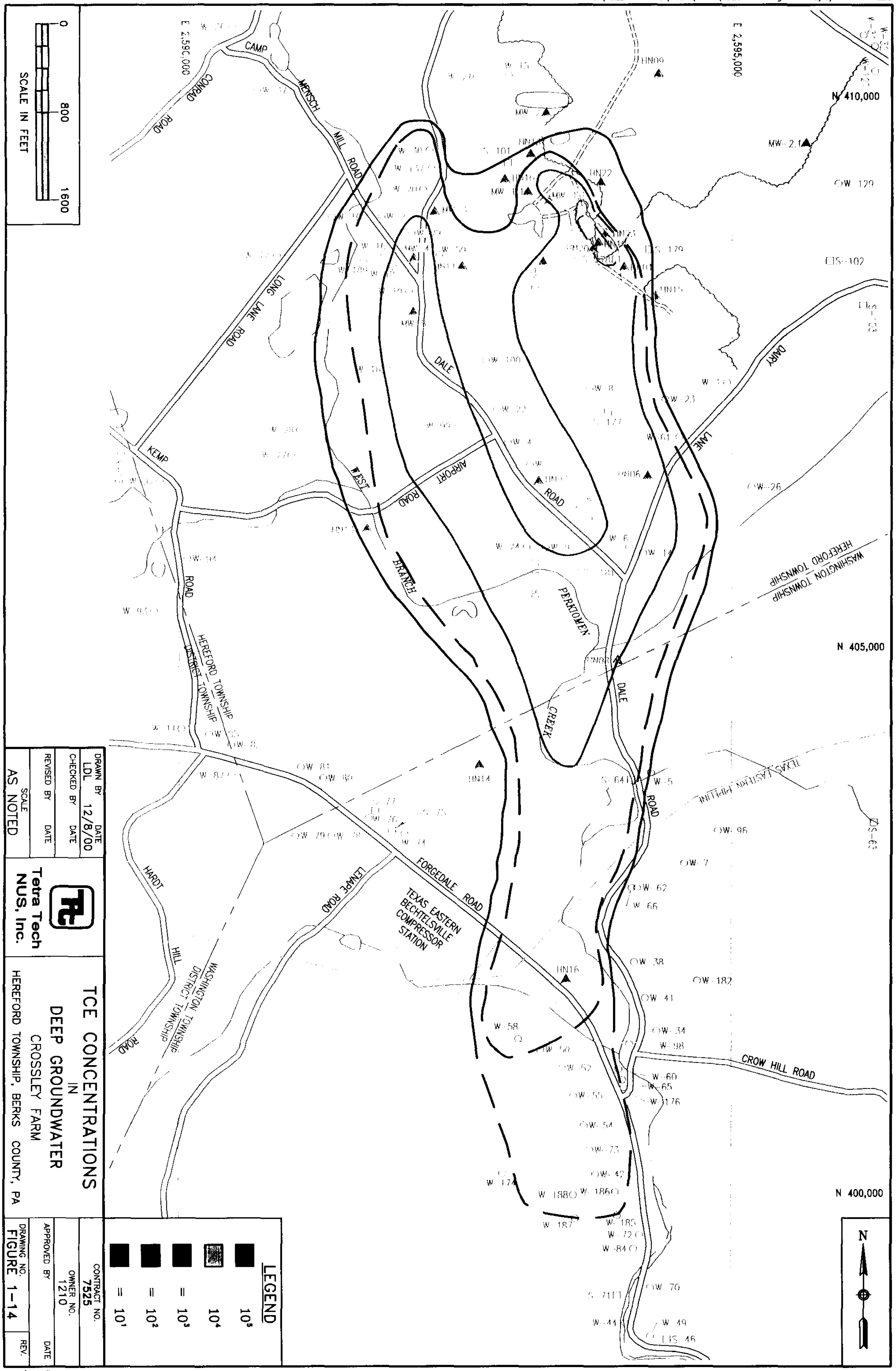

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Tetra Tech NUS, Inc.

TCE CONCENTRATIONS IN DEEP GROUNDWATER

CROSSLEY FARM

HEREFORD TOWNSHIP, BERKS COUNTY, PA

CONTRACT NO. 7525	
OWNER NO. 1210	
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DRAWING NO. FIGURE 1-14	REV.

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Figure 1-15 details the distribution of cis-1,2-DCE within the shallow groundwater zone in the immediate vicinity of the farm. As noted, all of the cis-1,2-DCE within the shallow groundwater zone occurs within a groundwater plume that appears to originate at the excavated drum (i.e., EPIC) pit, and is generally correlative to the western lobe of the TCE plume. The highest concentrations of cis-1,2-DCE were detected immediately downgradient of the excavated drum pit at monitoring well HN-18S (280 ug/L) and Spring No. 101 (SW/SD-11) (1,000 ug/L). There were no cis-1,2-DCE detections in the vicinity of and downgradient of the borrow pit, which is the area of the highest TCE concentrations. As outlined in the RI Report, the areal distribution of CIS-1,2-DEC in the shallow groundwater zone supports the conclusion that the excavated drum (i.e., EPIC) pit and the borrow pit are separate and distinct source areas.

Figure 1-16 details the distribution of cis-1,2-DCE within the intermediate groundwater zone in the immediate vicinity of the site. All of the cis-1,2-DCE within the intermediate groundwater zone occurs on Blackhead Hill or immediately adjacent to the hill within the Dale Valley. The highest concentration within this zone (240 ug/L) was detected in residential well W-20.

Nearly all of the cis-1,2-DCE within the deep groundwater zone occurs on Blackhead Hill or immediately adjacent to the hill, as shown on Figure 1-17. No cis-1,2-DCE was detected within any deep monitoring wells located south of the intersection of Dale Road and Dairy Lane. As noted in the RI, the vertical distribution pattern of cis-1,2-DCE within the plume emanating from the excavated drum or EPIC pit is similar to the distribution of TCE in the same area. That is, the contaminant is detected throughout the entire groundwater column, but the abundance of the chemical decreases significantly with increasing depth.

1.4.1.2 Other Organic Compounds

Other VOCs detected in on-site and off-site monitoring and/or residential wells occur at generally low concentrations and in distribution patterns that are restricted or inconsistent. VOCs identified included trichlorofluoromethane (TCFM), believed to be a site related contaminant, 1,1,2-trichloroethane (1,1,2-TCA); 1,1-dichlorothene (1,1-DCE); 1,2-dichloroethane (1,2-DCA); and vinyl chloride (VC). It is thought that some of these solvents are most likely breakdown products formed by the partial dechlorination of TCE or PCE.

Semi-volatile organic compounds were detected rarely within the groundwater throughout the study area. Compounds detected were largely limited to low concentrations of the phthalates that are considered to be common laboratory contaminants. Samples collected from the

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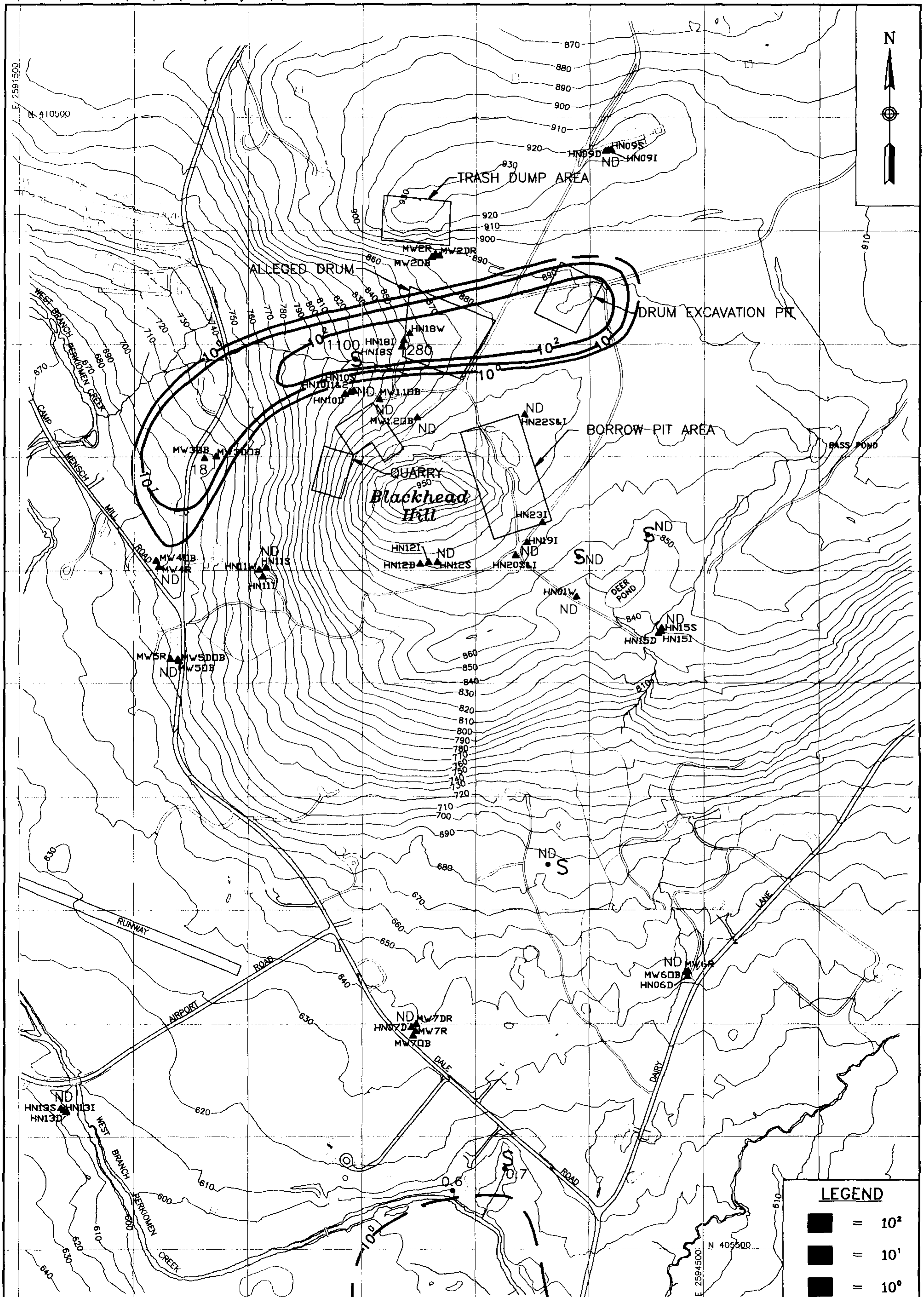

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CIS-1,2-Dichloroethene
CONCENTRATIONS
IN SHALLOW GROUNDWATER
CROSSLEY FARM
HEREFORD TOWNSHIP, BERKS COUNTY, PA

CONTRACT NO. 7525
OWNER NO. 1210
APPROVED BY DATE
DRAWING NO. FIGURE 1-15 REV.

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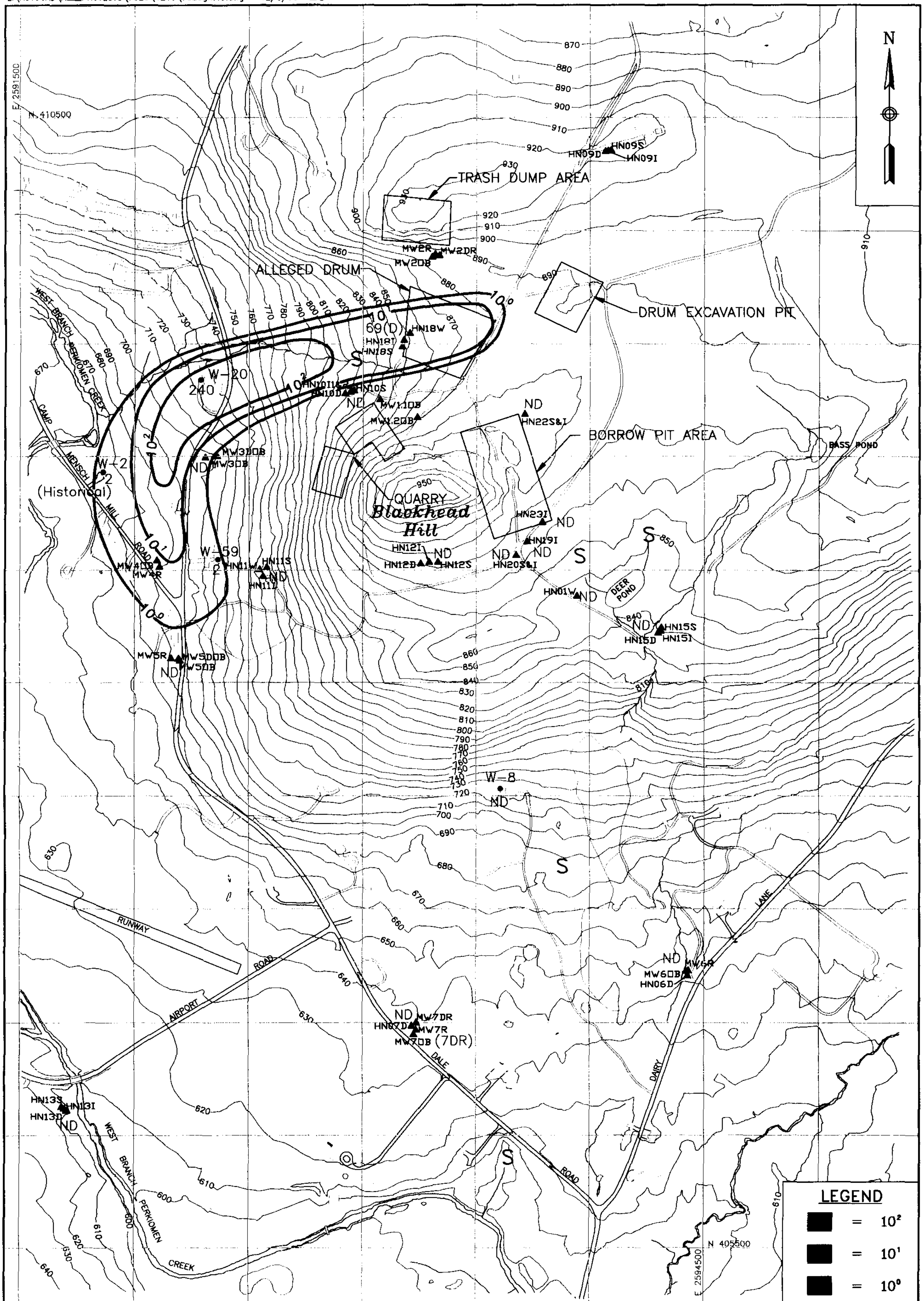

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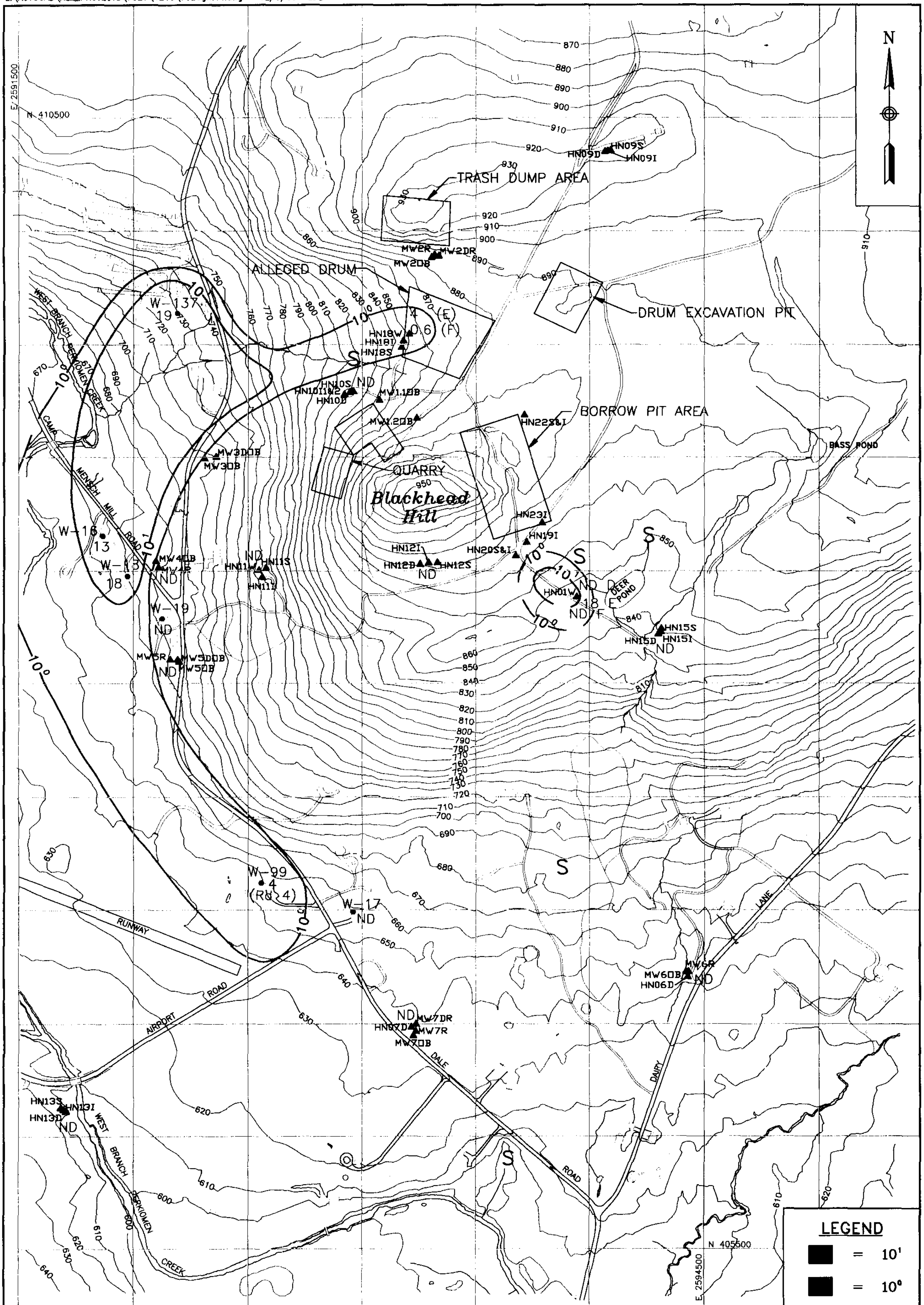

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Tetra Tech NUS, Inc.

CIS-1,2-Dichloroethene
CONCENTRATIONS
IN DEEP GROUNDWATER
CROSSLEY FARM
HEREFORD TOWNSHIP, BERKS COUNTY, PA

CONTRACT NO.	7525
OWNER NO.	1210
APPROVED BY	DATE
DRAWING NO. FIGURE 1-17	REV.

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residential well network exhibited similar results, that is SVOC detections were limited to phthalates, including bis(2-ethylhexyl) phthalate and di-n-butylphthalate. Based on the sampling results, pesticides were rarely detected in groundwater samples from throughout the study area. Aldrin was found in two monitoring wells (MW-4R and HN-15D), and endosulfan sulfate and endrin in one well each (HN-19I and MW-2.10B, respectively). The isolated detections are believed to be the result of the predominantly agricultural use of the lands throughout the study area. No pesticides were detected in any of the residential wells.

Aroclor-1260 was detected in a sample collected from the emanation point of Spring No. 177 (0.13 ug/L); no PCBs were detected within any on-site or off-site monitoring wells or residential supply wells.

1.4.1.3 Inorganics

Three inorganics, iron, manganese and lead, were selected as COPCs for the RI risk assessment based on sampling data and comparison to screening values. Statistical testing conducted during the RI, of the lead concentrations found in off-site residential wells to on-site concentrations, including background, concluded that the lead in the off-site potable wells is not attributable to the site. Supporting this conclusion is the qualitative observation that nearly all of the lead in the center-of-plume monitoring wells occurs in the total metals fraction, and is rarely detected in the dissolved metals fraction of each corresponding sample. Based on these results, the RI suggested that the lead detected on-site is not migrating as a dissolved phase within the groundwater.

The presence of iron and manganese in groundwater is believed to be attributable to the local geology, rather than the disposal of drummed waste at the farm. This hypothesis, is supported by the statistical background comparison that showed that iron is not elevated in the farm wells versus the upgradient wells, and the pervasive, elevated levels of iron and manganese in the residential wells throughout the study area, including those wells located outside of the VOC plume. The possibility does exist, however, that some of the manganese in the area groundwater may be attributable to the site activities, based on a qualitative analysis of the manganese detections.

1.4.2 <u>Surface Water</u>

Figure 1-18 details the locations where surface water and sediment samples were collected during the RI. Several of the surface water sampling locations are seeps or springs (including

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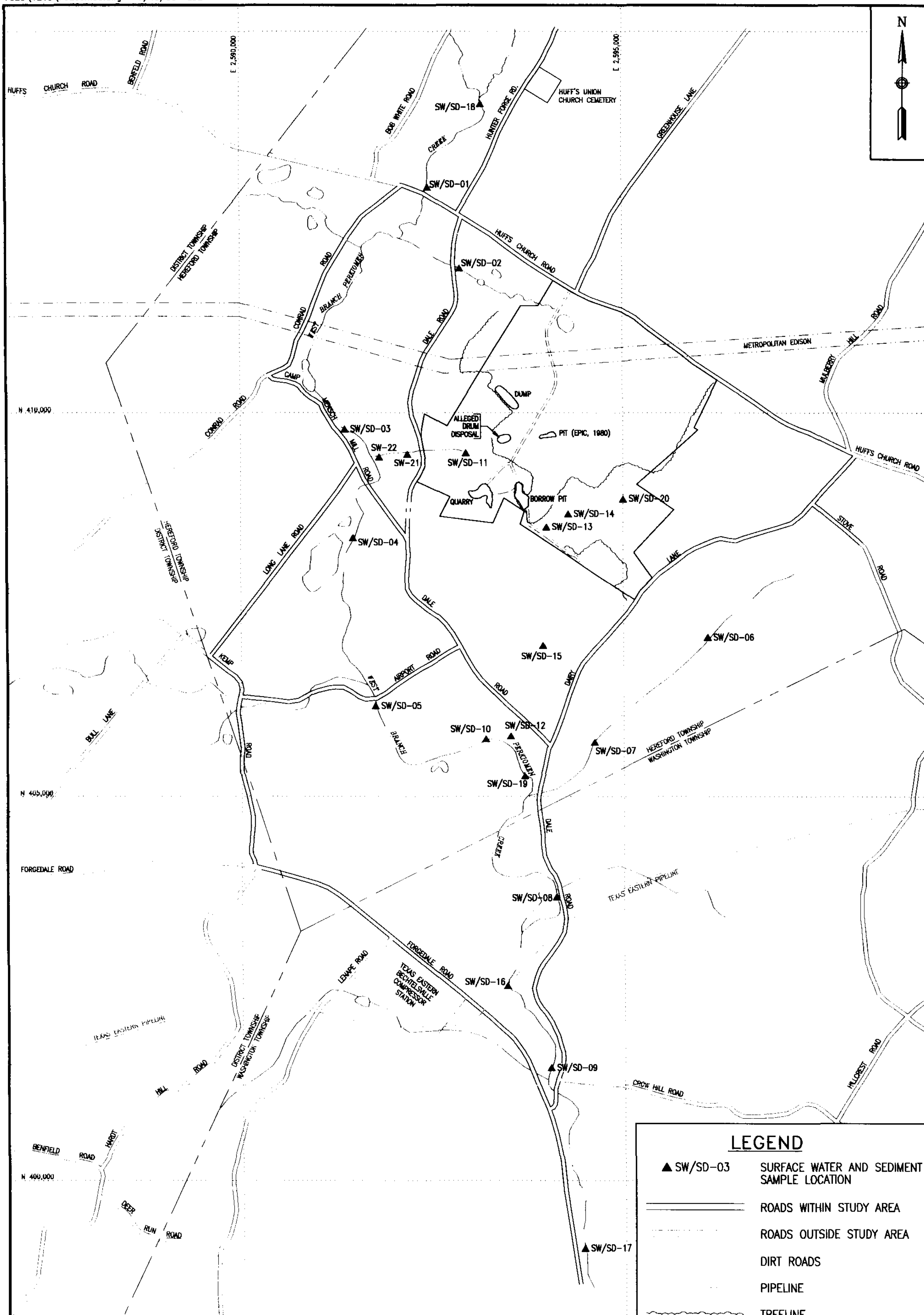

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Tetra Tech NUS, Inc.

SURFACE WATER & SEDIMENT SAMPLE LOCATION MAP

CROSSLEY FARM RI/FS

HEREFORD TOWNSHIP, BERKS COUNTY, PA

CONTRACT NO.	
7525	
OWNER NO.	
1210	
APPROVED BY	DATE
DRAWING NO. FIGURE 1-18	REV.

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SW-8, SW-10, SW-11, SW-12, SW-13, SW-14, and SW-15), that is, water emanating from these locations is groundwater that may or may not be originating from the site. Thus, depending upon which remedial alternative is selected for groundwater; the remediation may impact the nature and extent of contamination at one or more on-site or off-site seeps or springs.

A number of VOCs were detected in surface water samples collected from the study area, including TCE, PCE, and cis-1,2-DCE (see Figure 1-19). TCE concentrations ranged from non-detect to a maximum of 3,000 ug/L at location SW-11. PCE concentrations ranged from non-detect to 120 ug/L also at SW-11. SW-11 is a spring located along the western slope of Blackhead Hill within the topographic draw or saddle between the quarry and the Trash Dump ridge. As noted in the RI (TtNUS 2001), groundwater from both the excavated drum pit area and the northern part of the borrow pit, migrates through the area of SW-11, so it is not unexpected that the groundwater at the emanation point of the spring is highly contaminated with the same VOCs that contaminate the groundwater in the immediate vicinity of the spring. Trichlorofluoromethane, vinyl chloride, cis-1,2-DCE, and trans-1,2-DCE were other prominent VOCs detected at location SW-11. However, the number of VOCs detected and the level of contamination decreased at SW-11 as evidenced by the May/June 2000 sampling data. The decrease may be the result of the removal of the drums and contaminated soil from the EPIC pit.

Other locations that exhibited significantly elevated TCE levels were SW-13, SW-15 and SW-10. SW-13 is located immediately downgradient from the borrow pit and south of the corn field, just inside the tree line. Water at SW-13 discharges via a 4-inch piece of PVC pipe. The length and source of the pipe is not known but may be the discharge location for an agricultural field drainage system. Location SW-15 is a spring in a wooded area located on a private property along Dairy Lane. Water from the spring flows downhill through natural channeling. In the past, water from the spring may have been used for potable use, but based on current knowledge is no longer used. The fourth spring (SW-10) is at a private residence and feeds a small, rock-lined pool that discharges into the West Branch Perkiomen Creek. TCE was detected at a concentration of 486 ug/l in the first round of sampling conducted in early 1998, but was not detected in a later sampling event. PCE levels have remained consistent at 8.8 ug/l and 8 ug/l, respectively.

Significant concentrations of TCE are detected in the surface waters far downgradient from the site, including SW-16 (16 ug/L, 6,500 feet south of the borrow pit), SW-9 (11 ug/L, 7,500 feet south of the borrow pit), and SW-17 (14 ug/L, 10,000 feet south of the borrow pit).

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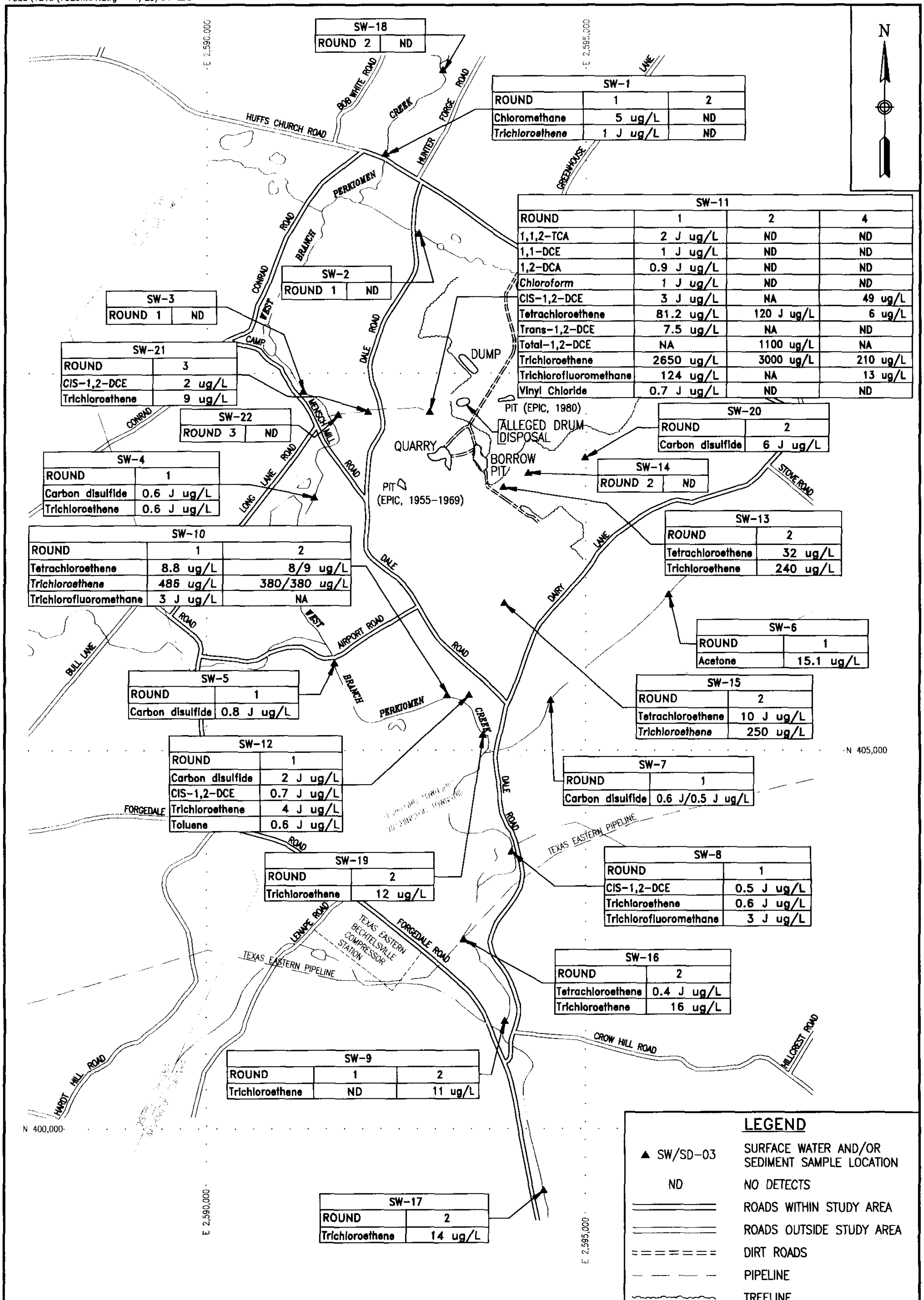

SW-18	
ROUND 2	ND

SW-1		
ROUND	1	2
Chloromethane	5 ug/L	ND
Trichloroethene	1 J ug/L	ND

SW-11			
ROUND	1	2	4
1,1,2-TCA	2 J ug/L	ND	ND
1,1-DCE	1 J ug/L	ND	ND
1,2-DCA	0.9 J ug/L	ND	ND
Chloroform	1 J ug/L	ND	ND
CIS-1,2-DCE	3 J ug/L	NA	49 ug/L
Tetrachloroethene	81.2 ug/L	120 J ug/L	6 ug/L
Trans-1,2-DCE	7.5 ug/L	NA	ND
Total-1,2-DCE	NA	1100 ug/L	NA
Trichloroethene	2650 ug/L	3000 ug/L	210 ug/L
Trichlorofluoromethane	124 ug/L	NA	13 ug/L
Vinyl Chloride	0.7 J ug/L	ND	ND

SW-2	
ROUND 1	ND

SW-3	
ROUND 1	ND

SW-21	
ROUND	3
CIS-1,2-DCE	2 ug/L
Trichloroethene	9 ug/L

SW-22	
ROUND 3	ND

SW-20	
ROUND	2
Carbon disulfide	6 J ug/L

SW-14	
ROUND 2	ND

SW-4	
ROUND	1
Carbon disulfide	0.6 J ug/L
Trichloroethene	0.6 J ug/L

SW-13	
ROUND	2
Tetrachloroethene	32 ug/L
Trichloroethene	240 ug/L

SW-10		
ROUND	1	2
Tetrachloroethene	8.8 ug/L	8/9 ug/L
Trichloroethene	486 ug/L	380/380 ug/L
Trichlorofluoromethane	3 J ug/L	NA

SW-6	
ROUND	1
Acetone	15.1 ug/L

SW-5	
ROUND	1
Carbon disulfide	0.8 J ug/L

SW-15	
ROUND	2
Tetrachloroethene	10 J ug/L
Trichloroethene	250 ug/L

SW-12	
ROUND	1
Carbon disulfide	2 J ug/L
CIS-1,2-DCE	0.7 J ug/L
Trichloroethene	4 J ug/L
Toluene	0.6 J ug/L

SW-7	
ROUND	1
Carbon disulfide	0.6 J/0.5 J ug/L

SW-19	
ROUND	2
Trichloroethene	12 ug/L

SW-8	
ROUND	1
CIS-1,2-DCE	0.5 J ug/L
Trichloroethene	0.6 J ug/L
Trichlorofluoromethane	3 J ug/L

SW-16	
ROUND	2
Tetrachloroethene	0.4 J ug/L
Trichloroethene	16 ug/L

SW-9		
ROUND	1	2
Trichloroethene	ND	11 ug/L

SW-17	
ROUND	2
Trichloroethene	14 ug/L

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SURFACE WATER SAMPLES
ANALYTICAL RESULTS
VOLATILE ORGANIC COMPOUNDS
CROSSLEY FARM SITE
HEREFORD TOWNSHIP, BERKS COUNTY, PA

CONTRACT NO. 7525
OWNER NO. 1210
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No SVOCs attributable to the site and site activities were detected. One pesticide (Delta-BHC) was detected at on-site location SW-20 (the Bass Pond), at a concentration of 0.0031 ug/L, and one PCB (Aroclor-1260) was detected at off-spring location SW-15 (downgradient of the borrow pit) at a concentration of 0.13 ug/L.

A number of inorganic compounds were detected in the surface water samples from the study area including aluminum, arsenic, barium, iron, manganese, thallium, beryllium, cyanide, chromium, lead, and zinc. Figure 1-20 details the inorganic results. The highest concentrations of many of the inorganics occurred at location SW-12. SW-12 is associated with a seep or spring, that based on its location receives discharge from the site. However, the inorganics are naturally occurring and are not related to the disposal of solvents at the farm. Cyanide was detected at four surface water locations; SW-11 (1.7 ug/l), SW-13 (1.8 ug/l), and SW-14 (1.5 ug/l) located on site immediately downgradient of the disposal areas. The fourth location, SW-7 (20 ug/l) is located off-site and downgradient of the borrow pit. Cyanide is likely attributable to the site.

1.4.3 Sediment

The distribution of VOCs in sediment samples is detailed in Figure 1-21. TCE was detected in six samples, ranging from 3 ug/l to 6,240 ug/l at location SD-11. PCE was detected in 5 samples, ranging from 2 ug/l to 65.1 ug/l also at SD-11. Cis-1,2-DCE was detected in 3 samples ranging from 3 ug/l to 158 ug/l. Again the highest concentration was at SD-11. Vinyl chloride was detected once, at location SD-10 at 4 ug/l.

A number of SVOCs, were detected at both on-site and off-site locations as detailed in Figure 1-22. However, based on the distribution of the data the RI concluded that the SVOCs detected in locations downgradient of the site, do not originate at the farm.

The detection of pesticides and PCBs in sediment samples was concluded in the RI to not be a result of the waste disposal activities at the site. Figure 1-23 details the distribution of inorganic compounds detected in on-site and off-site sediment samples. Based on the discussion outlined in the RI report, sediment locations HN-1 and HN-18 are considered background locations because they are hydraulically upgradient of the farm and include a number of inorganics chemicals of potential concern, that are also found throughout the study area. As further discussed, four sediment sample locations, SD-2, SD-8, SD-10, and SD-12 contain at least three inorganic chemicals of potential concern at their maximum detected concentrations.

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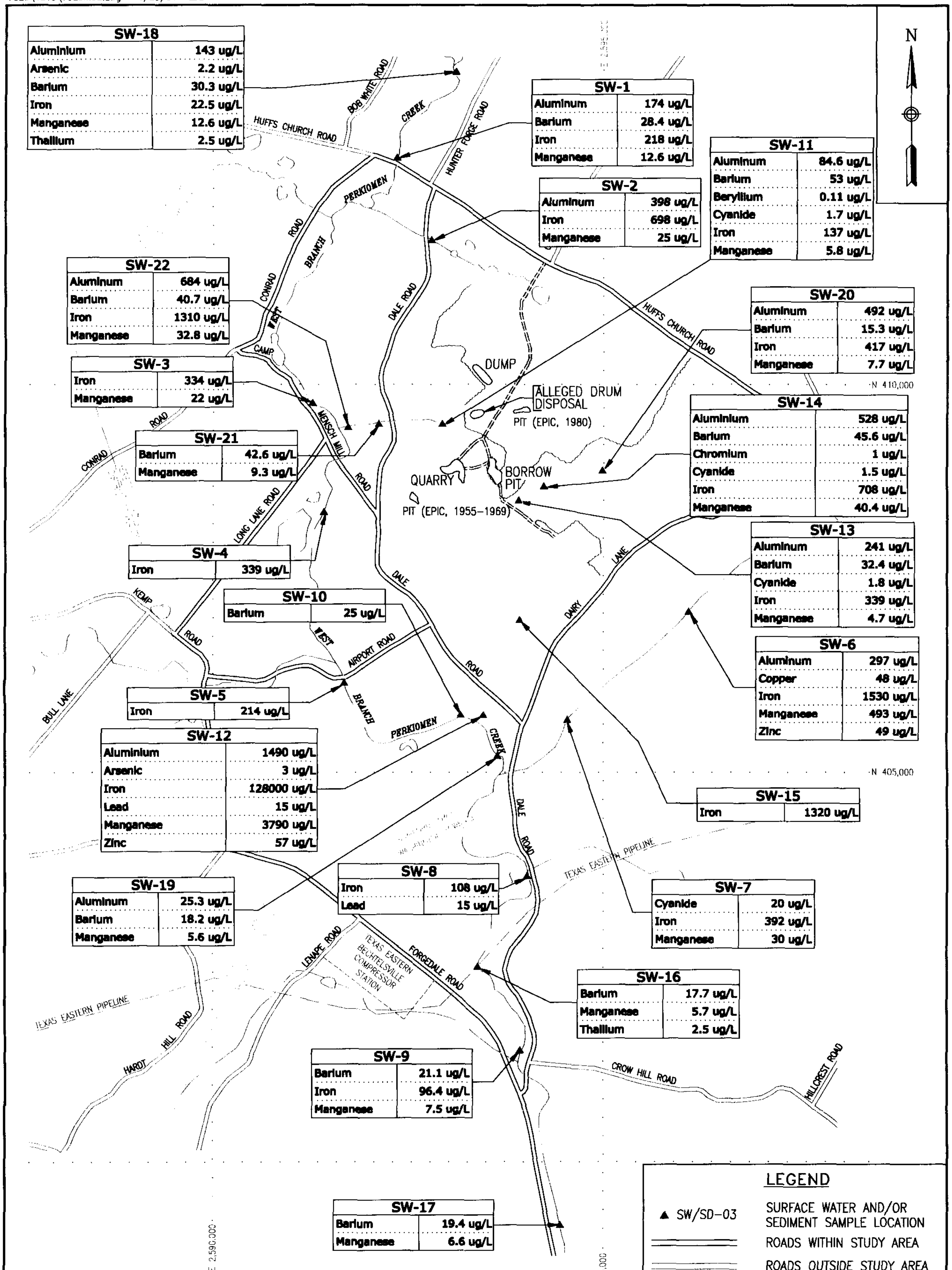

SW-18	
Aluminium	143 ug/L
Arsenic	2.2 ug/L
Barium	30.3 ug/L
Iron	22.5 ug/L
Manganese	12.6 ug/L
Thallium	2.5 ug/L

SW-1	
Aluminum	174 ug/L
Barium	28.4 ug/L
Iron	218 ug/L
Manganese	12.6 ug/L

SW-11	
Aluminum	84.6 ug/L
Barium	53 ug/L
Beryllium	0.11 ug/L
Cyanide	1.7 ug/L
Iron	137 ug/L
Manganese	5.8 ug/L

SW-2	
Aluminum	398 ug/L
Iron	698 ug/L
Manganese	25 ug/L

SW-22	
Aluminum	684 ug/L
Barium	40.7 ug/L
Iron	1310 ug/L
Manganese	32.8 ug/L

SW-20	
Aluminum	492 ug/L
Barium	15.3 ug/L
Iron	417 ug/L
Manganese	7.7 ug/L

SW-3	
Iron	334 ug/L
Manganese	22 ug/L

SW-14	
Aluminium	528 ug/L
Barium	45.6 ug/L
Chromium	1 ug/L
Cyanide	1.5 ug/L
Iron	708 ug/L
Manganese	40.4 ug/L

SW-21	
Barium	42.6 ug/L
Manganese	9.3 ug/L

SW-13	
Aluminum	241 ug/L
Barium	32.4 ug/L
Cyanide	1.8 ug/L
Iron	339 ug/L
Manganese	4.7 ug/L

SW-4	
Iron	339 ug/L

SW-10	
Barium	25 ug/L

SW-6	
Aluminum	297 ug/L
Copper	48 ug/L
Iron	1530 ug/L
Manganese	493 ug/L
Zinc	49 ug/L

SW-5	
Iron	214 ug/L

SW-12	
Aluminium	1490 ug/L
Arsenic	3 ug/L
Iron	128000 ug/L
Lead	15 ug/L
Manganese	3790 ug/L
Zinc	57 ug/L

SW-15	
Iron	1320 ug/L

SW-8	
Iron	108 ug/L
Lead	15 ug/L

SW-19	
Aluminum	25.3 ug/L
Barium	18.2 ug/L
Manganese	5.6 ug/L

SW-7	
Cyanide	20 ug/L
Iron	392 ug/L
Manganese	30 ug/L

SW-16	
Barium	17.7 ug/L
Manganese	5.7 ug/L
Thallium	2.5 ug/L

SW-9	
Barium	21.1 ug/L
Iron	96.4 ug/L
Manganese	7.5 ug/L

SW-17	
Barium	19.4 ug/L
Manganese	6.6 ug/L

LEGEND

- ▲ SW/SD-03 — SURFACE WATER AND/OR SEDIMENT SAMPLE LOCATION
- ROADS WITHIN STUDY AREA
- ROADS OUTSIDE STUDY AREA
- DIRT ROADS
- PIPELINE
- TREELINE

NOTE:

FOR EACH LOCATION, LISTED METALS ARE COPCs AT THAT PARTICULAR LOCATION.

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SURFACE WATER SAMPLES

INORGANIC COMPOUNDS

CROSSLEY FARM SITE

HEREFORD TOWNSHIP, BERKS COUNTY, PA

CONTRACT NO. 7525

OWNER NO. 1210

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DRAWING NO. FIGURE 1-20 REV.

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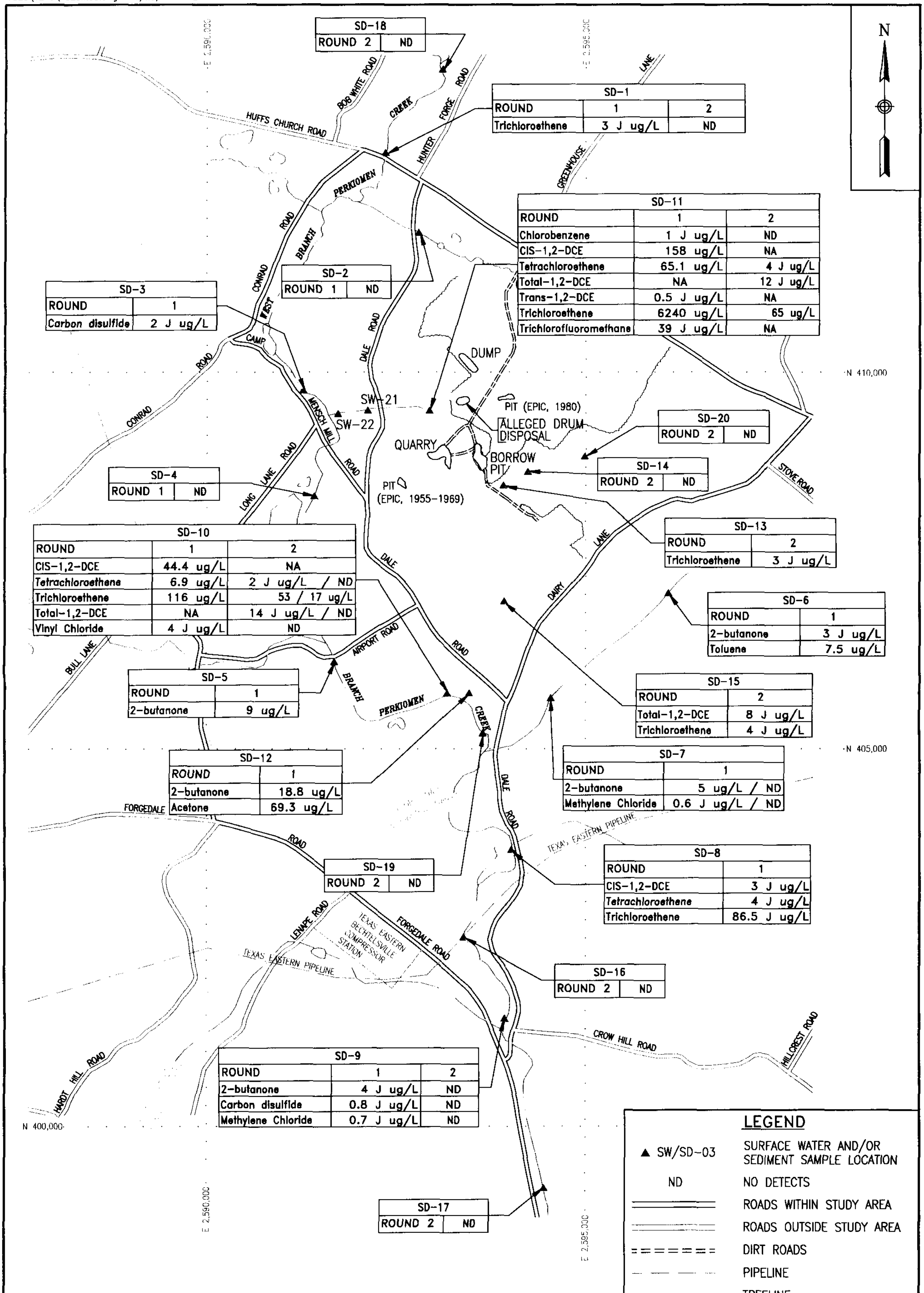

SD-18	
ROUND 2	ND

SD-1		
ROUND	1	2
Trichloroethene	3 J ug/L	ND

SD-11		
ROUND	1	2
Chlorobenzene	1 J ug/L	ND
CIS-1,2-DCE	158 ug/L	NA
Tetrachloroethene	65.1 ug/L	4 J ug/L
Total-1,2-DCE	NA	12 J ug/L
Trans-1,2-DCE	0.5 J ug/L	NA
Trichloroethene	6240 ug/L	65 ug/L
Trichlorofluoromethane	39 J ug/L	NA

SD-2	
ROUND 1	ND

SD-3	
ROUND	1
Carbon disulfide	2 J ug/L

SD-20	
ROUND 2	ND

SD-14	
ROUND 2	ND

SD-4	
ROUND 1	ND

SD-13	
ROUND	2
Trichloroethene	3 J ug/L

SD-10		
ROUND	1	2
CIS-1,2-DCE	44.4 ug/L	NA
Tetrachloroethene	6.9 ug/L	2 J ug/L / ND
Trichloroethene	116 ug/L	53 / 17 ug/L
Total-1,2-DCE	NA	14 J ug/L / ND
Vinyl Chloride	4 J ug/L	ND

SD-6	
ROUND	1
2-butanone	3 J ug/L
Toluene	7.5 ug/L

SD-5	
ROUND	1
2-butanone	9 ug/L

SD-15	
ROUND	2
Total-1,2-DCE	8 J ug/L
Trichloroethene	4 J ug/L

SD-12	
ROUND	1
2-butanone	18.8 ug/L
Acetone	69.3 ug/L

SD-7	
ROUND	1
2-butanone	5 ug/L / ND
Methylene Chloride	0.6 J ug/L / ND

SD-8	
ROUND	1
CIS-1,2-DCE	3 J ug/L
Tetrachloroethene	4 J ug/L
Trichloroethene	86.5 J ug/L

SD-19	
ROUND 2	ND

SD-16	
ROUND 2	ND

SD-9		
ROUND	1	2
2-butanone	4 J ug/L	ND
Carbon disulfide	0.8 J ug/L	ND
Methylene Chloride	0.7 J ug/L	ND

SD-17	
ROUND 2	ND

LEGEND

- ▲ SW/SD-03 — SURFACE WATER AND/OR SEDIMENT SAMPLE LOCATION
- ND — NO DETECTS
- ROADS WITHIN STUDY AREA
- ROADS OUTSIDE STUDY AREA
- DIRT ROADS
- PIPELINE
- TREELINE

0 1200 2400
SCALE IN FEET

DRAWN BY LDL	DATE 1/23/01
CHECKED BY	DATE
REVISED BY	DATE
SCALE AS NOTED	

Tetra Tech NUS, Inc.

SEDIMENT SAMPLES
ANALYTICAL RESULTS
VOLATILE ORGANIC COMPOUNDS
CROSSLEY FARM SITE
HEREFORD TOWNSHIP, BERKS COUNTY, PA

CONTRACT NO. 7525	
OWNER NO. 1210	
APPROVED BY	DATE
DRAWING NO. FIGURE 1-21	REV.

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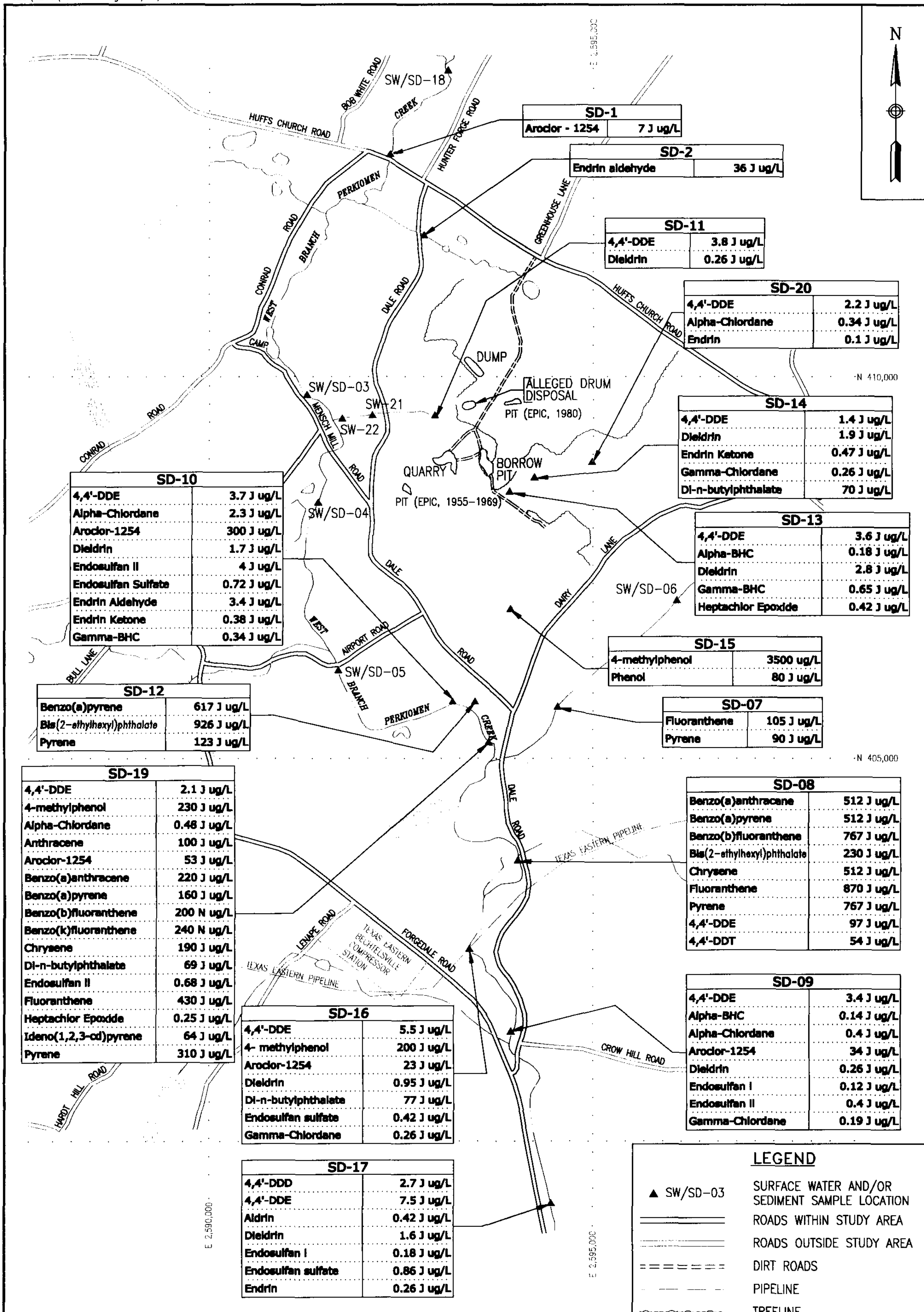

SD-1	
Aroclor - 1254	7 J ug/L

SD-2	
Endrin aldehyde	36 J ug/L

SD-11	
4,4'-DDE	3.8 J ug/L
Dieldrin	0.26 J ug/L

SD-20	
4,4'-DDE	2.2 J ug/L
Alpha-Chlordane	0.34 J ug/L
Endrin	0.1 J ug/L

SD-14	
4,4'-DDE	1.4 J ug/L
Dieldrin	1.9 J ug/L
Endrin Ketone	0.47 J ug/L
Gamma-Chlordane	0.26 J ug/L
Di-n-butylphthalate	70 J ug/L

SD-10	
4,4'-DDE	3.7 J ug/L
Alpha-Chlordane	2.3 J ug/L
Aroclor-1254	300 J ug/L
Dieldrin	1.7 J ug/L
Endosulfan II	4 J ug/L
Endosulfan Sulfate	0.72 J ug/L
Endrin Aldehyde	3.4 J ug/L
Endrin Ketone	0.38 J ug/L
Gamma-BHC	0.34 J ug/L

SD-13	
4,4'-DDE	3.6 J ug/L
Alpha-BHC	0.18 J ug/L
Dieldrin	2.8 J ug/L
Gamma-BHC	0.65 J ug/L
Heptachlor Epoxide	0.42 J ug/L

SD-15	
4-methylphenol	3500 ug/L
Phenol	80 J ug/L

SD-12	
Benzo(a)pyrene	617 J ug/L
Bis(2-ethylhexyl)phthalate	926 J ug/L
Pyrene	123 J ug/L

SD-07	
Fluoranthene	105 J ug/L
Pyrene	90 J ug/L

SD-19	
4,4'-DDE	2.1 J ug/L
4-methylphenol	230 J ug/L
Alpha-Chlordane	0.48 J ug/L
Anthracene	100 J ug/L
Aroclor-1254	53 J ug/L
Benzo(a)anthracene	220 J ug/L
Benzo(a)pyrene	160 J ug/L
Benzo(b)fluoranthene	200 N ug/L
Benzo(k)fluoranthene	240 N ug/L
Chrysene	190 J ug/L
Di-n-butylphthalate	69 J ug/L
Endosulfan II	0.68 J ug/L
Fluoranthene	430 J ug/L
Heptachlor Epoxide	0.25 J ug/L
Ideno(1,2,3-cd)pyrene	64 J ug/L
Pyrene	310 J ug/L

SD-08	
Benzo(a)anthracene	512 J ug/L
Benzo(a)pyrene	512 J ug/L
Benzo(b)fluoranthene	767 J ug/L
Bis(2-ethylhexyl)phthalate	230 J ug/L
Chrysene	512 J ug/L
Fluoranthene	870 J ug/L
Pyrene	767 J ug/L
4,4'-DDE	97 J ug/L
4,4'-DDT	54 J ug/L

SD-16	
4,4'-DDE	5.5 J ug/L
4- methylphenol	200 J ug/L
Aroclor-1254	23 J ug/L
Dieldrin	0.95 J ug/L
Di-n-butylphthalate	77 J ug/L
Endosulfan sulfate	0.42 J ug/L
Gamma-Chlordane	0.26 J ug/L

SD-09	
4,4'-DDE	3.4 J ug/L
Alpha-BHC	0.14 J ug/L
Alpha-Chlordane	0.4 J ug/L
Aroclor-1254	34 J ug/L
Dieldrin	0.26 J ug/L
Endosulfan I	0.12 J ug/L
Endosulfan II	0.4 J ug/L
Gamma-Chlordane	0.19 J ug/L

SD-17	
4,4'-DDD	2.7 J ug/L
4,4'-DDE	7.5 J ug/L
Aldrin	0.42 J ug/L
Dieldrin	1.6 J ug/L
Endosulfan I	0.18 J ug/L
Endosulfan sulfate	0.86 J ug/L
Endrin	0.26 J ug/L

LEGEND

▲ SW/SD-03	SURFACE WATER AND/OR SEDIMENT SAMPLE LOCATION
	ROADS WITHIN STUDY AREA
	ROADS OUTSIDE STUDY AREA
	DIRT ROADS
	PIPELINE
	TREELINE

0 1200 2400

SCALE IN FEET

DRAWN BY LDL	DATE 1/23/01
CHECKED BY	DATE
REVISED BY	DATE
SCALE AS NOTED	

Tetra Tech NUS, Inc.

SEDIMENT SAMPLES
ANALYTICAL RESULTS
SEMIVOLATILE ORGANIC COMPOUNDS
AND PCBs/PESTICIDES
CROSSLEY FARM SITE
HEREFORD TOWNSHIP, BERKS COUNTY, PA

CONTRACT NO. 7525	
OWNER NO. 1210	
APPROVED BY	DATE
DRAWING NO. FIGURE 1-22	REV.

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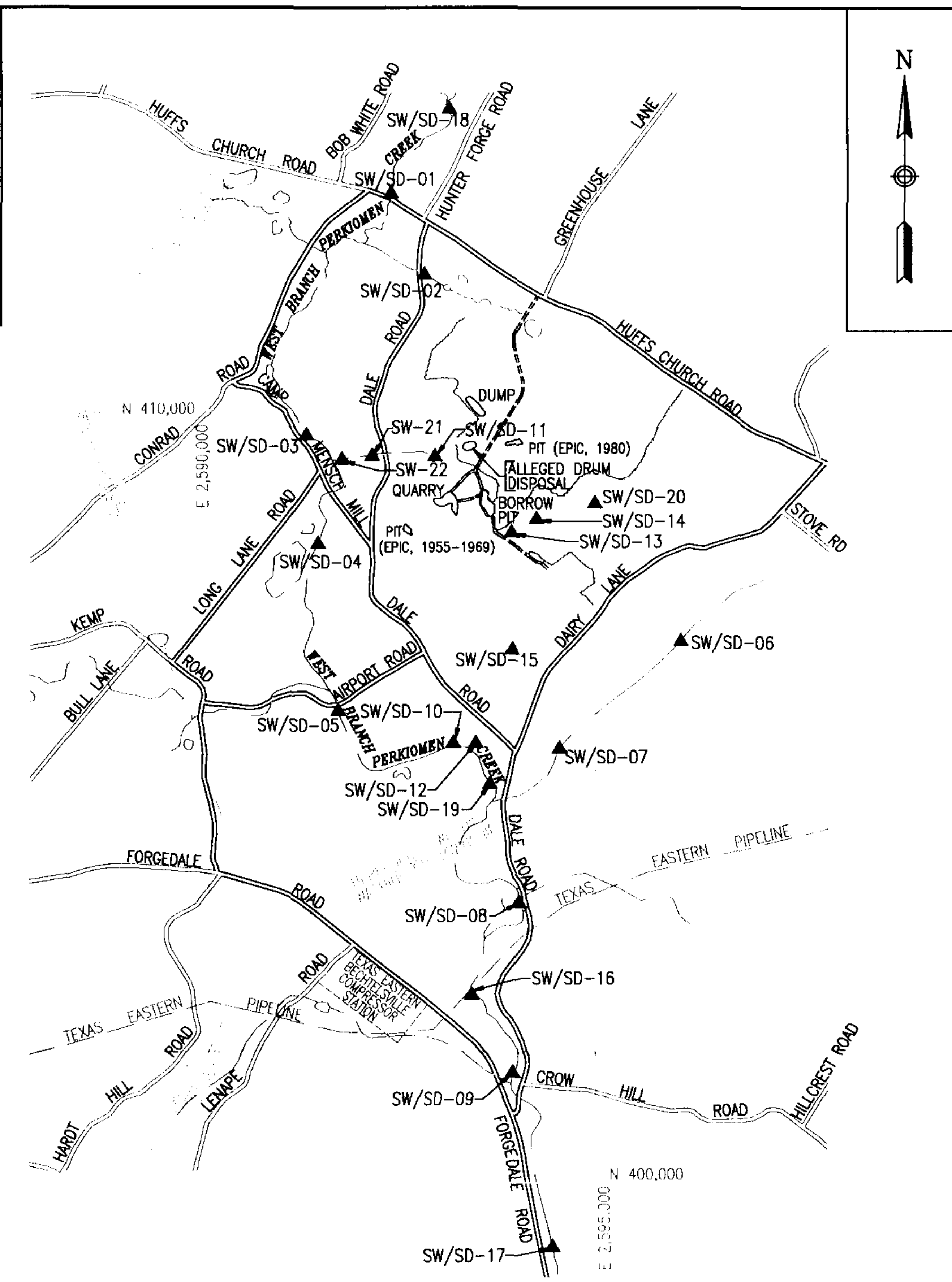
LEGEND

▲ SW/SD-03	SURFACE WATER AND/OR SEDIMENT SAMPLE LOCATION
ND	NO DETECTS
	ROADS WITHIN STUDY AREA
	ROADS OUTSIDE STUDY AREA
	DIRT ROADS
	PIPELINE
	TREELINE



	SD-1	SD-2	SD-3	SD-4	SD-5	SD-6	SD-7	SD-8	SD-9	SD-10	SD-11	SD-12	SD-13	SD-14	SD-15	SD-16	SD-17	SD-18	SD-19	SD-20
ALUMINUM	2070	17200	10800	8280	10100	3000	3840	18900	4540	9070	7580	22200	8800	12800	1510	5790	12700	4670	3770	12800
ANTIMONY						0.5 L														
ARSENIC	0.97 L	2.3		1.1	1.7	0.5	0.5	3.6	0.89 L	3.3 L	1.1	18.3	3.1	3.8	0.52	1.1 L	2.8 L	1.9 L	1.3 L	4.4
BARIUM	23.3	96.3	55.4	57	65.4	20.1	24.3	138	48	88	185	166	41.3	78.4	14.1	60.6	127	45.4	43.8	56.4
BERYLLIUM	0.31	1		0.6	0.7			1.8	0.65	2.3	0.85	1.6	0.74	0.89	0.3	0.79	1.5	0.54	0.52	0.89
CADMIUM										0.85				0.1		0.43	0.79			0.11
CHROMIUM	3.6	59.6	21.4	21.1	19	4.1	3.9	26.2	10.2	25.6	12.4	20.9	11.9	19.6	3.9	12.7	25.1	8.3	11.2	12.4
COBALT	2.3	17.4		7.1	8.2			17.5	4.3	13.7	6.4	14.1	5.5	13.4	0.56	6.4	9	4	6.4	4.4
COPPER		17.2	3.2	7.7	7.9	4	2.7	35.5			6.9	27.8	6.5	8.3	3.4	21.1			14.2	9.2
CYANIDE									0.31	10.2	0.14		0.25	0.43	0.13		14.2			0.27
IRON	5570 J	32600	6490	15900	16500	4750	5250	37500	9340 J	36700 J	13500	92200	15100	19700	5100	12300 J	18400 J	9370 J	10600 J	15100
LEAD		11.8	3.9	10.4	13.8	7.5	9.3	246			14	62.7		21.7		20.9 J				28.5
MANGANESE	188	702	121	188	360	65.3	54.5	597	145	534	840	1300	167	1190	12.2	411	326	279	353	218
MERCURY								3.4				0.1								5.2
NICKEL	1.8	17.2	5.4	7	8.3			18.5	4.4	27.8	4.6	28.5	3.8	6.1	0.7	5.5	9.7	2.1	3.9	
SELENIUM								1.5		1.7 L		1.5		0.8 L						
SILVER									0.34 L	2.7 L	0.4 L		0.3 L	0.62 L	0.27 L	0.43 L	0.71 L		0.41 L	0.4 L
THALLIUM								0.3				0.6								
VANADIUM		66.6	25.8	29.5	29.1	7	6.4	41.5	16.6	33.7	17.5	41	21.3	34	5.4	21.3	38.5	18.8	17.6	26
ZINC		72.2	20.2	56	50.5	26.8	24.8	229		219	31.7	263	37.2	43.6		66.8	148		47	39.3

0 1800 3600

SCALE IN FEET

DRAWN BY LDL DATE 1/23/01

CHECKED BY DATE

REVISED BY DATE

SCALE AS NOTED

Tetra Tech NUS, Inc.

SEDIMENT SAMPLES ANALYTICAL RESULTS INORGANIC COMPOUNDS

CROSSLEY FARM SITE

HEREFORD TOWNSHIP, BERKS COUNTY, PA

CONTRACT NO. 7525

OWNER NO. 1210

APPROVED BY DATE

DRAWING NO. FIGURE 1-23 REV.

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However, based on a qualitative analysis and data collected during the RI, the occurrence and distribution of inorganics in sediments is most likely not related to the disposal of solvents at the farm.

1.4.4 Soil

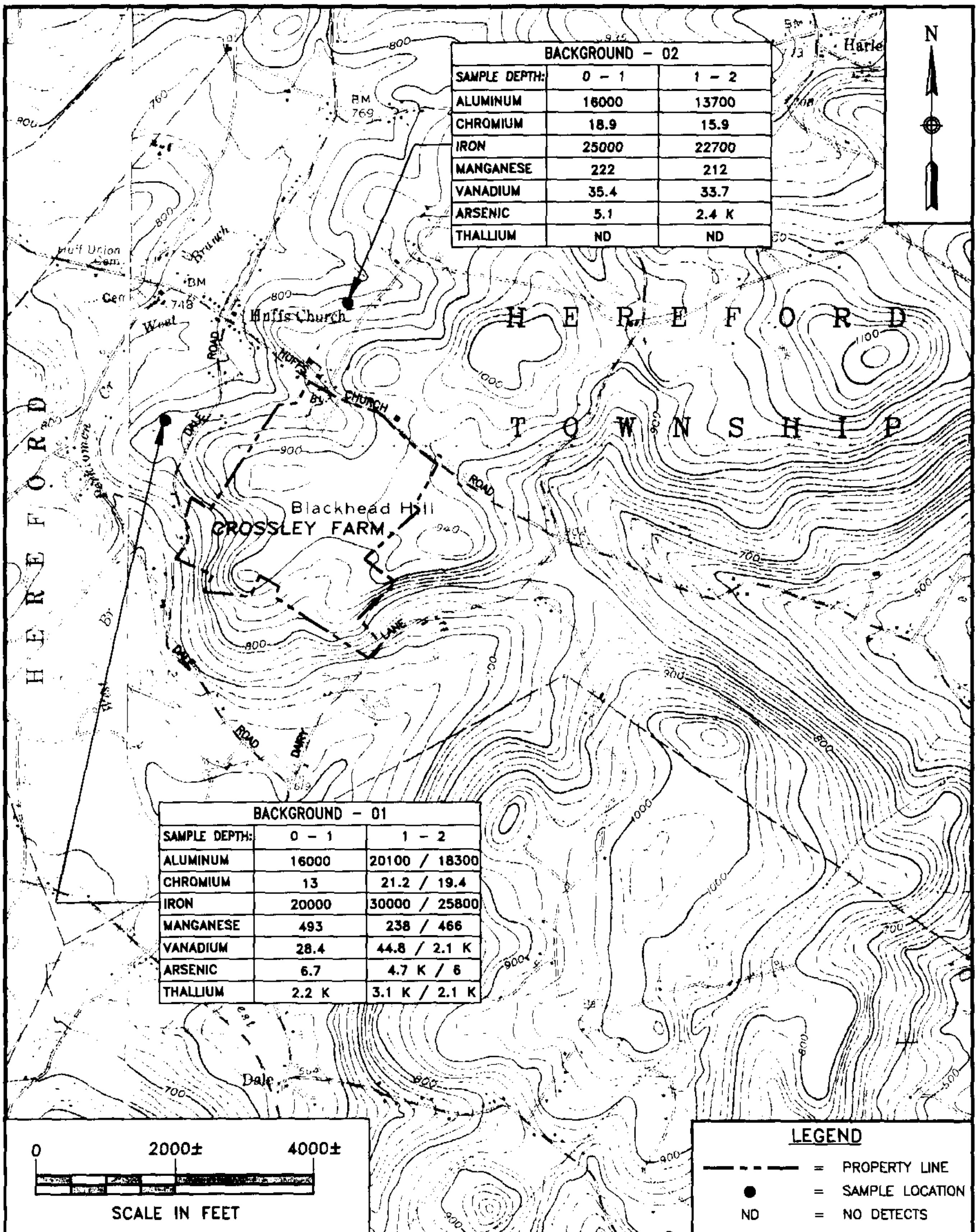
Soil samples were collected as part of the RI site activities and the drum removal action conducted during the summer of 1998. Results from the soil sampling conducted during the drum removal action are not included in this document.

During the RI a number of soil samples, including background locations were collected and analyzed. Surface soil, subsurface soil and test pit soil samples were collected. Detailed information concerning the sampling locations, methodology and analysis are presented in the RI report. Figure 1-24 details the background surface soil sample locations and results. No volatile or semi-volatile organic compounds, pesticides or PCBs were detected in the background samples.

Figure 1-25 details the sample locations where VOCs were detected. VOC occurrences within the soils were rare and when present, at low concentrations. TCE was detected in the surface soil (SB-6 at 4 ug/kg and SB-8 at 22 ug/kg) and subsurface soils (SB-8 at 4 ug/kg) adjacent to the borrow pit. PCE was detected in the surface soil at SB-8 (10 ug/kg). The presence of PCE and TCE in borings SB-6 and SB-8 confirms that the borrow pit was a location of solvent disposal. As noted in the RI, the relatively low concentrations of VOCs that were detected would appear to indicate that the bulk of the disposal occurred within soils that have subsequently been removed (creating the borrow pit), and that little contaminated soil remains in this area to act as a residual source of contamination.

Based on the low concentration of TCE detected in sample TP-1, the RI concluded that the trash dump area is not a major contributor to the groundwater solvent plume.

Figure 1-26 details the extent of semi-volatile compounds detected in soil samples collected at the site. SVOC occurrences within the site soils were relatively rare, consisted primarily of PAHs and were limited to a few locations. The majority of SVOCs were detected in samples TP-1 and TP-2 collected from the trash dump and SB-1.



BACKGROUND - 02		
SAMPLE DEPTH:	0 - 1	1 - 2
ALUMINUM	16000	13700
CHROMIUM	18.9	15.9
IRON	25000	22700
MANGANESE	222	212
VANADIUM	35.4	33.7
ARSENIC	5.1	2.4 K
THALLIUM	ND	ND

BACKGROUND - 01		
SAMPLE DEPTH:	0 - 1	1 - 2
ALUMINUM	16000	20100 / 18300
CHROMIUM	13	21.2 / 19.4
IRON	20000	30000 / 25800
MANGANESE	493	238 / 466
VANADIUM	28.4	44.8 / 2.1 K
ARSENIC	6.7	4.7 K / 6
THALLIUM	2.2 K	3.1 K / 2.1 K

0 2000± 4000±

SCALE IN FEET

LEGEND

- PROPERTY LINE
- ● = SAMPLE LOCATION
- ND = NO DETECTS

DRAWN BY LDL DATE 1/23/01	Tetra Tech NUS, Inc.	BACKGROUND SOIL SAMPLES	CONTRACT NO. 7525
CHECKED BY DATE		INORGANIC COMPOUNDS	OWNER NO. 1210
REVISED BY DATE		CROSSLEY FARM	APPROVED BY DATE
SCALE AS NOTED		HEREFORD TOWNSHIP, BERKS COUNTY, PA	DRAWING NO. FIGURE 1-24 REV.

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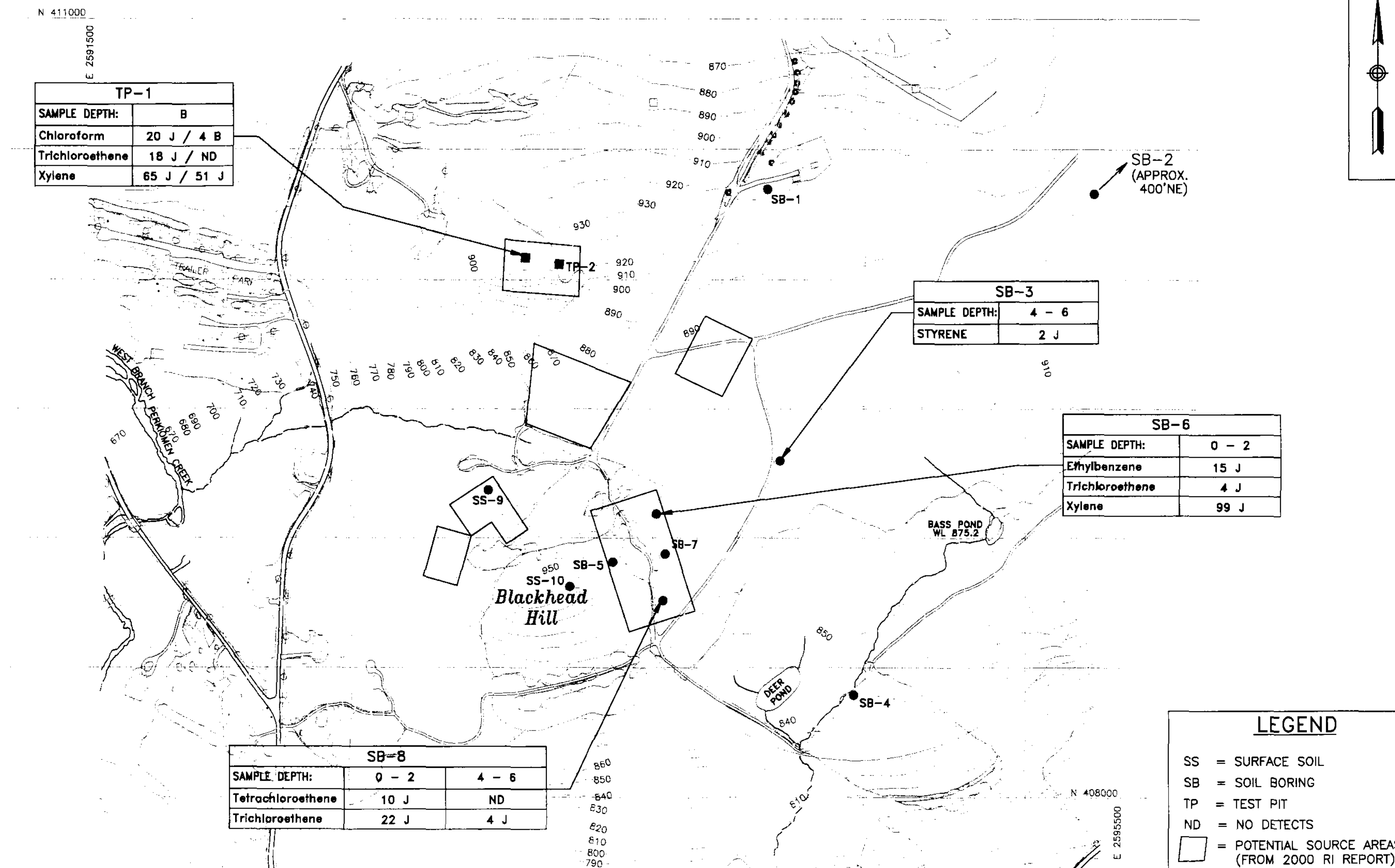

TP-1	
SAMPLE DEPTH:	B
Chloroform	20 J / 4 B
Trichloroethene	18 J / ND
Xylene	65 J / 51 J

SB-3	
SAMPLE DEPTH:	4 - 6
STYRENE	2 J

SB-6	
SAMPLE DEPTH:	0 - 2
Ethylbenzene	15 J
Trichloroethene	4 J
Xylene	99 J

SB-8		
SAMPLE DEPTH:	0 - 2	4 - 6
Tetrachloroethene	10 J	ND
Trichloroethene	22 J	4 J

LEGEND

SS = SURFACE SOIL
SB = SOIL BORING
TP = TEST PIT
ND = NO DETECTS
☐ = POTENTIAL SOURCE AREAS (FROM 2000 RI REPORT)

0 400 800
SCALE IN FEET

NOTE:
ALL RESULTS REPORTED IN ug/kg.

DRAWN BY LDL	DATE 01/23/01	Tetra Tech NUS, Inc.	SOIL SAMPLES ANALYTICAL RESULTS VOLATILE ORGANIC COMPOUNDS CROSSLEY FARM HEREFORD TOWNSHIP, BERKS COUNTY, PA	CONTRACT NO. 7525
CHECKED BY	DATE			OWNER NO. 1210
REVISED BY	DATE			APPROVED BY / DATE
SCALE AS NOTED				DRAWING NO. FIGURE 1-25 / REV.

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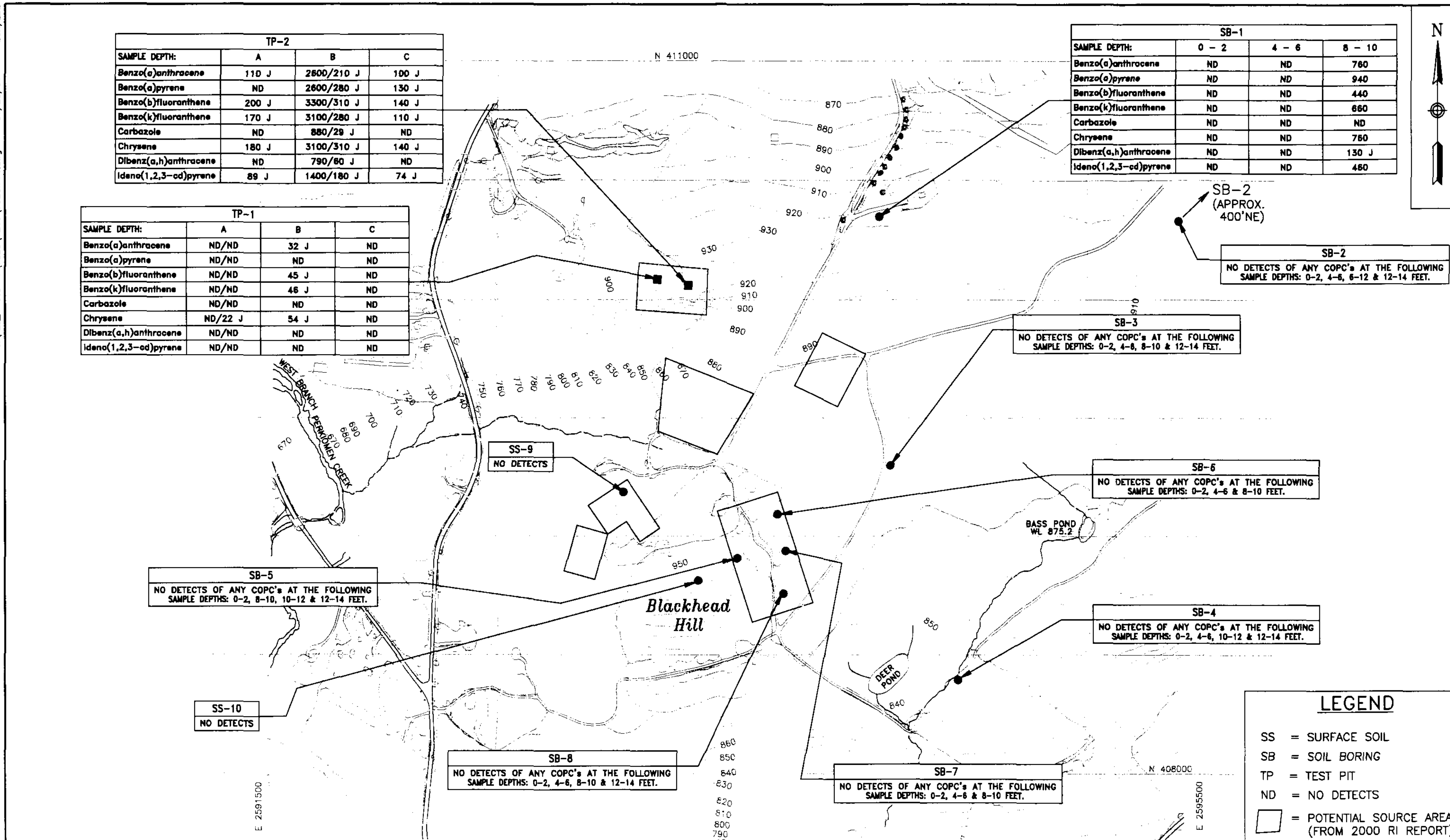


TP-2			
SAMPLE DEPTH:	A	B	C
Benzo(a)anthracene	110 J	2600/210 J	100 J
Benzo(a)pyrene	ND	2600/280 J	130 J
Benzo(b)fluoranthene	200 J	3300/310 J	140 J
Benzo(k)fluoranthene	170 J	3100/280 J	110 J
Carbazole	ND	880/29 J	ND
Chrysene	180 J	3100/310 J	140 J
Dibenz(a,h)anthracene	ND	790/60 J	ND
Ideno(1,2,3-cd)pyrene	89 J	1400/180 J	74 J

TP-1			
SAMPLE DEPTH:	A	B	C
Benzo(a)anthracene	ND/ND	32 J	ND
Benzo(a)pyrene	ND/ND	ND	ND
Benzo(b)fluoranthene	ND/ND	45 J	ND
Benzo(k)fluoranthene	ND/ND	46 J	ND
Carbazole	ND/ND	ND	ND
Chrysene	ND/22 J	54 J	ND
Dibenz(a,h)anthracene	ND/ND	ND	ND
Ideno(1,2,3-cd)pyrene	ND/ND	ND	ND

SB-1			
SAMPLE DEPTH:	0 - 2	4 - 6	8 - 10
Benzo(a)anthracene	ND	ND	760
Benzo(a)pyrene	ND	ND	940
Benzo(b)fluoranthene	ND	ND	440
Benzo(k)fluoranthene	ND	ND	660
Carbazole	ND	ND	ND
Chrysene	ND	ND	760
Dibenz(a,h)anthracene	ND	ND	130 J
Ideno(1,2,3-cd)pyrene	ND	ND	460

NOTE:

ALL RESULTS REPORTED IN ug/kg.

DRAWN BY LDL DATE 01/23/01	Tetra Tech NUS, Inc.	SOIL SAMPLES ANALYTICAL RESULTS SEMIVOLATILE COMPOUNDS OF POTENTIAL CONCERN (COPC'S) CROSSLEY FARM HEREFORD TOWNSHIP, BERKS COUNTY, PA	CONTRACT NO. 7525
CHECKED BY DATE			OWNER NO. 1210
REVISED BY DATE			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-26 REV.

Pesticides were found at a number of locations at the site, however, generally at low concentrations, and based on the results no pesticide compound was selected as a chemical of potential concern for the baseline human health risk assessment. Aroclor-1260 was detected in samples from several locations including, immediately uphill from the borrow pit (SB-5, 40 ug/kg); along the base of the quarry talus slope (SS-9; 260 ug/kg) and at the trash dump (TP-1, 1,000 ug/kg). Figure 1-27 details the sample locations.

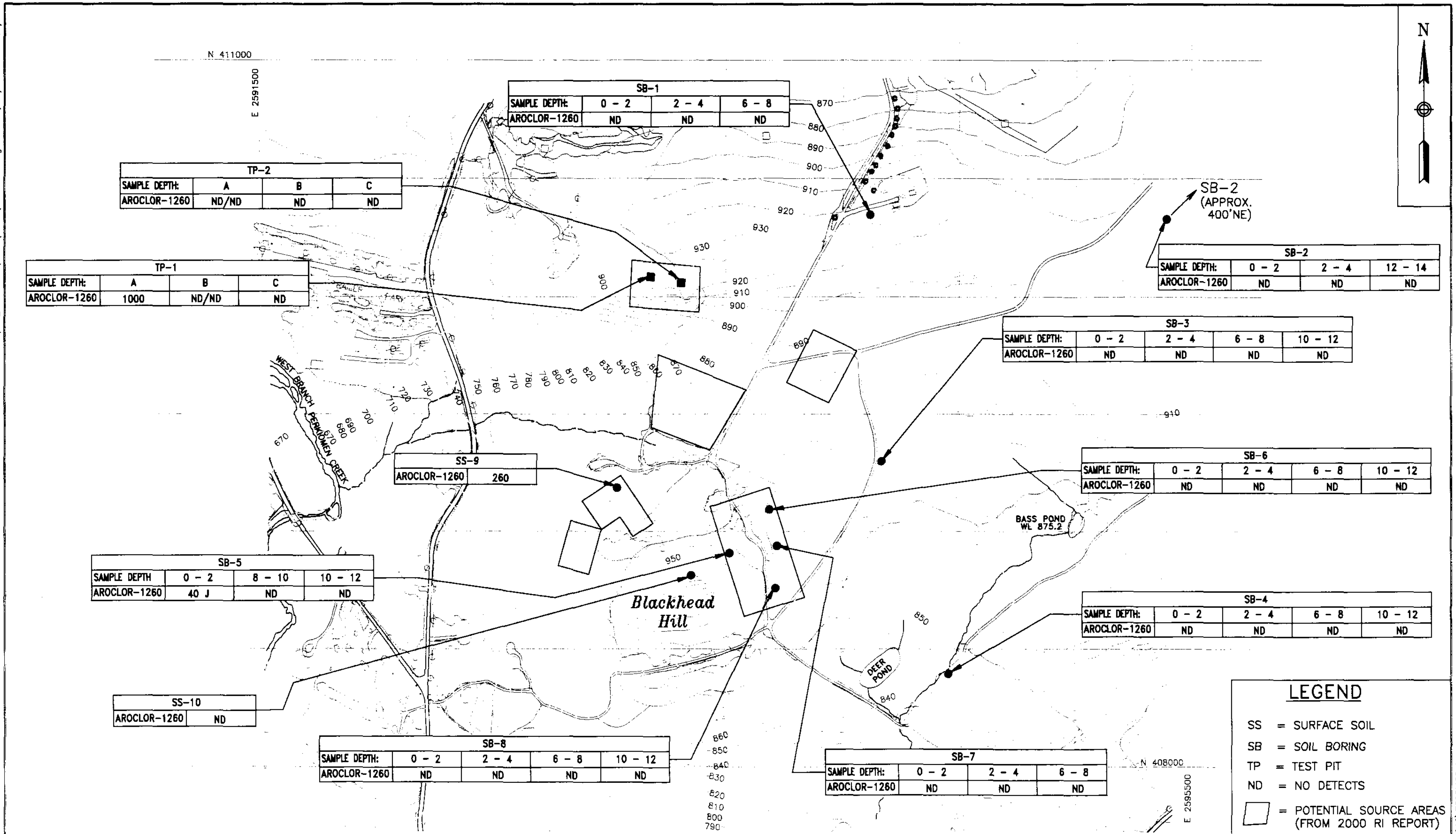
Figure 1-28 details the inorganic compounds detected in site soils that were selected as COPCs for the risk assessment based on concentrations and frequency of detections. The COPCs for the soil medium include aluminum, chromium, iron, manganese, and vanadium. For soils at the trash dump, the listed compounds plus arsenic and thallium were selected as COPCs.

Most of the metals occur at most of the locations for both the surface and subsurface soils. That is, the RI concluded that there does not appear to be any discernable patterns regarding the presence or absence of any metal relative to the waste source areas at the borrow pit and the EPIC pit. There are no "hot spots" of elevated metal concentrations, and there is no correlation between the nature and extent of the metals and the locations of the hazardous waste disposal or staging areas (i.e., drum excavation are or borrow pit). The presence of the metals at the detected concentrations is interpreted to result from a combination of the natural soil and bedrock mineralogy, and the introduction of metals through the historical application of crop fertilizers and the more recent application of the concentrated biosolids for crops.

1.5 RISK ASSESSMENT SUMMARY

1.5.1 Human Health Risk Assessment

A baseline human health risk assessment (BLRA) was prepared for the Crossley Farm Site as part of the RI activities (i.e., site BLRA). The general objectives of the risk assessment were to estimate the actual or potential risks to human health resulting from the presence of contamination in area groundwater (center of plume plus one potential potable spring), surface soil, total soil, test pit soil, sediment, and surface water. In addition, a BLRA was prepared for potable water sources (i.e., residential wells) located within the study area. The Crossley Farm Site Baseline Risk Assessment for Potable Water Sources was submitted to EPA in July 2000 (TtNUS, 2000). Groundwater risks at the existing residential wells within the study area (i.e., potable water sources) were calculated individually and evaluated current exposures to child and adult residents. As outlined in the January 2001 RI Report (TtNUS, 2001), the specific objectives of the site BLRA are as follows



0 400 800
SCALE IN FEET

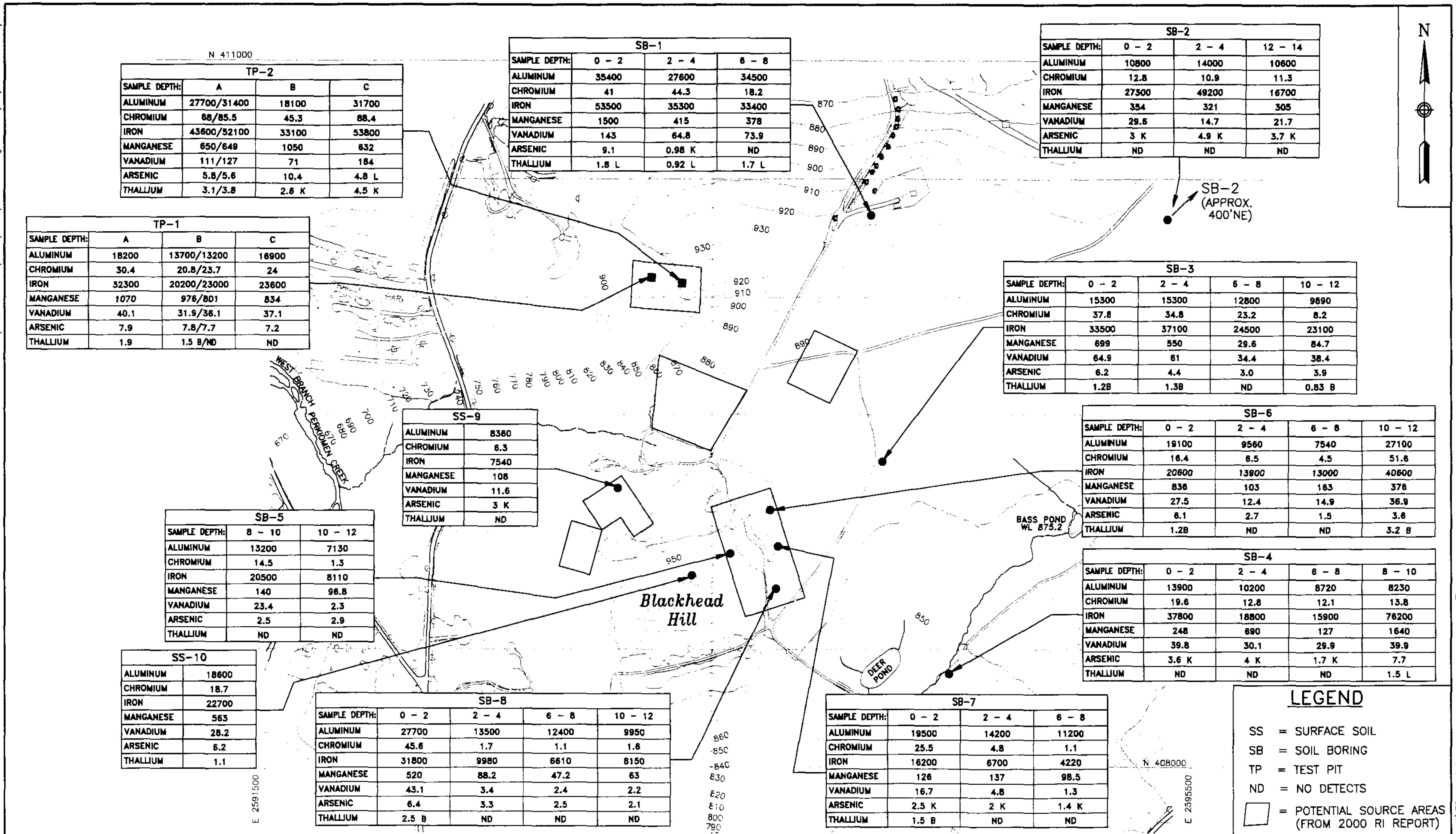
NOTE:
ALL RESULTS REPORTED IN mg/kg.

DRAWN BY LDL	DATE 01/23/01
CHECKED BY	DATE
REVISED BY	DATE
SCALE AS NOTED	

Tetra Tech NUS, Inc.

SOIL SAMPLES
ANALYTICAL RESULTS
PESTICIDES/PCB's COMPOUNDS OF POTENTIAL CONCERN (COPC'S)
CROSSLEY FARM
HEREFORD TOWNSHIP, BERKS COUNTY, PA

CONTRACT NO. 7525	
OWNER NO. 1210	
APPROVED BY	DATE
DRAWING NO. FIGURE 1-27	REV.



TP-2

SAMPLE DEPTH:	A	B	C
ALUMINUM	27700/31400	18100	31700
CHROMIUM	68/85.5	45.3	88.4
IRON	43600/52100	33100	53800
MANGANESE	650/649	1050	632
VANADIUM	111/127	71	184
ARSENIC	5.8/5.6	10.4	4.8 L
THALLIUM	3.1/3.8	2.6 K	4.5 K

TP-1

SAMPLE DEPTH:	A	B	C
ALUMINUM	18200	13700/13200	16900
CHROMIUM	30.4	20.8/23.7	24
IRON	32300	20200/23000	23600
MANGANESE	1070	976/801	834
VANADIUM	40.1	31.9/36.1	37.1
ARSENIC	7.9	7.8/7.7	7.2
THALLIUM	1.9	1.5 B/ND	ND

SB-1

SAMPLE DEPTH:	0 - 2	2 - 4	6 - 8
ALUMINUM	35400	27600	34500
CHROMIUM	41	44.3	18.2
IRON	53500	35300	33400
MANGANESE	1500	415	378
VANADIUM	143	64.8	73.9
ARSENIC	9.1	0.98 K	ND
THALLIUM	1.8 L	0.92 L	1.7 L

SB-2

SAMPLE DEPTH:	0 - 2	2 - 4	12 - 14
ALUMINUM	10800	14000	10600
CHROMIUM	12.8	10.9	11.3
IRON	27300	49200	16700
MANGANESE	354	321	305
VANADIUM	29.6	14.7	21.7
ARSENIC	3 K	4.9 K	3.7 K
THALLIUM	ND	ND	ND

SB-3

SAMPLE DEPTH:	0 - 2	2 - 4	6 - 8	10 - 12
ALUMINUM	15300	15300	12800	9890
CHROMIUM	37.8	34.8	23.2	8.2
IRON	33500	37100	24500	23100
MANGANESE	699	550	29.6	84.7
VANADIUM	64.9	61	34.4	38.4
ARSENIC	6.2	4.4	3.0	3.9
THALLIUM	1.2B	1.3B	ND	0.83 B

SS-9

ALUMINUM	8360
CHROMIUM	6.3
IRON	7540
MANGANESE	108
VANADIUM	11.6
ARSENIC	3 K
THALLIUM	ND

SB-6

SAMPLE DEPTH:	0 - 2	2 - 4	6 - 8	10 - 12
ALUMINUM	19100	9560	7540	27100
CHROMIUM	16.4	8.5	4.5	51.6
IRON	20600	13900	13000	40600
MANGANESE	836	103	163	376
VANADIUM	27.5	12.4	14.9	36.9
ARSENIC	6.1	2.7	1.5	3.6
THALLIUM	1.2B	ND	ND	3.2 B

SB-5

SAMPLE DEPTH:	8 - 10	10 - 12
ALUMINUM	13200	7130
CHROMIUM	14.5	1.3
IRON	20500	8110
MANGANESE	140	96.8
VANADIUM	23.4	2.3
ARSENIC	2.5	2.9
THALLIUM	ND	ND

SB-4

SAMPLE DEPTH:	0 - 2	2 - 4	6 - 8	8 - 10
ALUMINUM	13900	10200	8720	8230
CHROMIUM	19.6	12.8	12.1	13.8
IRON	37800	18800	15900	76200
MANGANESE	248	690	127	1640
VANADIUM	39.8	30.1	29.9	39.9
ARSENIC	3.6 K	4 K	1.7 K	7.7
THALLIUM	ND	ND	ND	1.5 L

SS-10

ALUMINUM	18600
CHROMIUM	18.7
IRON	22700
MANGANESE	563
VANADIUM	28.2
ARSENIC	6.2
THALLIUM	1.1

SB-8

SAMPLE DEPTH:	0 - 2	2 - 4	6 - 8	10 - 12
ALUMINUM	27700	13500	12400	9950
CHROMIUM	45.6	1.7	1.1	1.6
IRON	31800	9980	6610	8150
MANGANESE	520	88.2	47.2	63
VANADIUM	43.1	3.4	2.4	2.2
ARSENIC	6.4	3.3	2.5	2.1
THALLIUM	2.5 B	ND	ND	ND

SB-7

SAMPLE DEPTH:	0 - 2	2 - 4	6 - 8
ALUMINUM	19500	14200	11200
CHROMIUM	25.5	4.8	1.1
IRON	16200	6700	4220
MANGANESE	126	137	98.5
VANADIUM	16.7	4.8	1.3
ARSENIC	2.5 K	2 K	1.4 K
THALLIUM	1.5 B	ND	ND

LEGEND

SS = SURFACE SOIL

SB = SOIL BORING

TP = TEST PIT

ND = NO DETECTS

☐ = POTENTIAL SOURCE AREAS (FROM 2000 RI REPORT)

NOTE:

ALL RESULTS REPORTED IN mg/kg.

DRAWN BY LDL	DATE 01/23/01	Tetra Tech NUS, Inc.	SOIL SAMPLES ANALYTICAL RESULTS INORGANIC COMPOUNDS CROSSLEY FARM HEREFORD TOWNSHIP, BERKS COUNTY, PA	CONTRACT NO. 7525	
CHECKED BY	DATE			OWNER NO. 1210	
REVISED BY	DATE			APPROVED BY	DATE
SCALE AS NOTED				DRAWING NO. FIGURE 1-28	REV.

- To estimate the actual or potential risks to human health resulting from the presence of contamination in surface soil, total soil, test pit soil, sediment, surface water, and area groundwater at designated areas/media of concern, including site surface and subsurface soils, one groundwater plume, and sediment/surface water from the Perkiomen Creek and its tributaries watershed.

- To provide a basis for attainment of concentrations that are protective of potential human receptors under residential, industrial, recreational, and construction exposure scenarios.

- To determine the need for remedial measures (if applicable) for these media.

Potential receptors chosen for the Crossley Farm Site were selected based on current and anticipated future land use, accessibility to the site, and media of concern. As previously noted, the site is currently used for agricultural purposes (i.e., light industrial) and is surrounded by adjacent farms and/or residential properties. The future anticipated land use at the site is expected to be for agricultural purposes (i.e., commercial or light industrial). Likely potential receptors under this land use scenario include light industrial (farm) workers, construction workers, and recreational receptors. Residential land use is also a potential scenario for this site, therefore, residential risks were also considered. Residential land use scenarios may also determine whether land-use restrictions are warranted at the site. The potential receptors identified in the BLRA were residents (current/future exposures), recreational receptors (current/future exposures), industrial workers (future exposures), construction workers (future exposures), and farm residents (future exposure).

Potential exposure estimation routes, methods, and models outlined in the BLRA were consistent with current EPA risk assessment guidance. Noncarcinogenic risks were estimated using the concept of an average annual exposure. Noncarcinogenic risks for some exposure routes (e.g., soil) were generally greater for children than for adults because of differences in body weight and intake. Carcinogenic risks were estimated as an incremental lifetime risk and therefore, incorporate terms to average the exposure duration (years) over the course of a lifetime (70 years).

Based on the risk analysis non-carcinogenic RME risk exceedances were identified for the following media and receptors: area groundwater (residential child, residential adult, adult industrial worker, and adult construction worker); surface soil (residential child); total soil (residential child) test pit soil (residential child) and sediment during wading activities (residential child, recreational adult). Non-carcinogenic exceedances were determined if the (HI) Hazard

Index value was greater than 1.0. If the value of the HI exceeds 1.0, there is a potential noncarcinogenic health risk associated with exposure to that chemical mixture. It is a numerical indicator of the possibility of the occurrence of noncarcinogenic (threshold) effects.

EPA has defined the range of 1×10^{-4} to 1×10^{-6} as the incremental cancer risk (ICR) "target range" for most hazardous waste facilities addressed under CERCLA. Based on the site BLRA, the area groundwater receptors identified with RME carcinogenic risks exceeding EPA's target risk of 1×10^{-4} included residential child, residential adult, lifetime resident, and adult industrial worker.

Based on the potable water sources risk assessment carcinogenic risks for a lifetime resident exceeded 1.0×10^{-4} for residential groundwater wells such that two clusters or hotspots, located downgradient of the site were identified. One cluster, consisting of wells RW016, RW018, RW019, RW020, RW020, RW029, and RW059, is located due west of Crossley Farm along Dale Road. The second cluster, consisting of wells RW-008, RW009, RW022, RW061, and RW099, is located south of the farm and is along and near the intersection of Dale Road and Dairy Lane. These two hot spots correspond to the two lobes of the most highly contaminated residential groundwater wells as delineated in the RI Report (TtNUS, 2001).

1.5.2 Ecological Risk Assessment

The Ecological Risk Assessment (ERA), presented in the January 2001 RI Report (TtNUS, 2001), evaluated the potential ecological impacts and risks at the site through the performance of an ecological screening task and a food chain modeling task. The ecological screening compared the chemical concentrations from site samples of environmental media (surface soil, surface water, and sediment) against the medium-specific benchmark concentrations for those chemicals that are recognized as having little potential for adverse impacts to organisms inhabiting those media.

These concentrations, developed by the EPA Region III Biological Technical Assistance Group (BTAG), are purposefully conservative so as to be protective of the most sensitive floral and faunal receptors. The ecological screening addressed potential risk to endpoints involving adverse effects on small and relatively immobile ecological receptors that directly inhabit soil, sediment, or surface water.

Food chain modeling was conducted to assess the potential risk to ecological receptors feeding upon environmental media (such as water and soil) or food sources (such as plants or invertebrates) impacted by chemical constituents at the site. The modeling estimated doses of site-related compounds received by larger, more mobile ecological receptors that were exposed to multiple environmental media on the site. The estimated doses were then compared against doses reported in the scientific literature as having little or no potential for adverse effects to similar receptors. The food chain modeling for the Crossley Farm Site focused on several species of terrestrial wildlife and birds likely to drink the surface water and feed on various plants and invertebrates inhabiting the upland soils and wetlands on the site.

The screening value assessment and the food chain modeling suggested that the concentrations of certain constituents at the Crossley Farm Site may be adversely affecting some of the more sensitive ecological receptors, especially those receptors that are relatively immobile and spend extended periods of time localized within areas of maximal contaminant concentrations. However, even the highest concentrations of these constituents do not vastly exceed the corresponding ecological screening levels established by EPA (i.e., BTAG values), and even the highest doses estimated through food chain modeling do not vastly exceed the corresponding Lowest Observed Adverse Effects Levels (LOAELS) established as dose benchmarks for the more mobile bird and terrestrial wildlife receptors. Based on these findings the ERA concluded that the results suggest that any adverse effects are likely modest, and may only involve the most sensitive receptor species present on the site. They do no suggest a likelihood of widespread substantial impacts to the overall ecosystem. Furthermore, the distributions of the highest concentrations of most constituents suggest that areas of high concentration are localized within small areas. Any ecologically significant impacts, such as reductions in the population of certain highly sensitive receptor species, would therefore be expected to be localized, and not felt over the overall site and adjoining areas.

Results of the food chain modeling suggested that certain constituents could potentially have adverse impacts on certain small terrestrial wildlife and bird individuals that obtain all or most of their food and water from the small areas on the site with maximal concentrations of chemical constituents. Even with its very conservative underlying assumptions, the food chain modeling suggested that adverse impacts to higher level predators are unlikely.

The final conclusion outlined in the ERA was that no further investigation or remediation solely to address ecological receptors was recommended for the Crossley Farm Site. The highest concentrations of most constituents on the site occur in sediments located within the small seepage wetlands on forested slopes. If the results of the ecological screening and food chain modeling were conservatively interpreted to require sediment excavation, that excavation would result in the physical destruction of several small but complex wetlands that would be difficult to reconstruct, regardless of budget. Even if successfully restored, several decades would be necessary for newly planted trees to attain the size necessary to shade the restored wetlands so as to provide habitat conditions resembling current conditions. The ecological impacts resulting from the excavation of wetland sediment, even if the wetlands were restored to the best of available technology, would likely be greater than the limited toxicological impacts to ecological receptors resulting from leaving the existing sediment in place.

2

2.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES

2.1 INTRODUCTION

This section presents the objectives for remedial action and the factors used in the development of remedial action alternatives. Chemicals of concern and media identified in the RI are also presented in this section. Also detailed are the regulatory requirements and guidance [Applicable or Relevant and Appropriate Requirements (ARARs)] that may be applied to the remedial activities. Proposed clean-up levels or Preliminary Remediation Goals (PRGs) for remediation are also detailed.

2.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) AND TO BE CONSIDERED (TBCs) CRITERIA

Applicable or Relevant and Appropriate Requirements (ARARs) are any standard, requirement, criterion, or limitation outlined under Federal or state environmental law. This includes any promulgated standard, requirement, criteria, or limitation under a state environmental or facility-siting law that is more stringent than the associated Federal standard, requirement, criterion, or limitation. To be considered criteria (TBCs) are nonpromulgated, nonenforceable guidelines, or criteria that may be useful for developing a remedial action or are necessary for determining what is protective to human health and/or the environment. Examples of TBCs include U.S. EPA's Drinking Water Health Advisories, Reference Doses (RDs), and Cancer Slope Factors (CSFs).

2.2.1 <u>Identification of ARARs and TBCs</u>

Tables 2-1, 2-2, and 2-3 present a list of potential Federal and State (i.e., Commonwealth) of Pennsylvania chemical, location, and action-specific ARARs and TBCs that may be applicable to the selection and/or implementation of remedial measures at the Crossley Farm Site. Most of these ARARs and TBCs provide some medium-specific guidance on acceptable or permissible concentrations of contaminants. The following sections briefly describe the different types of potential ARARs and TBCs.

2.2.1.1 Chemical-Specific ARARs and TBCs

Chemical-specific ARARs and TBCs are usually health-or risk-based numerical values that are used to establish the acceptable amount or concentration of a chemical that may remain in, or be discharged to, the environment. In general, chemical-specific requirements are set for a single

TABLE 2-1
SUMMARY OF CHEMICAL-SPECIFIC ARARs AND TBCs FOR
POTENTIAL USE AT THE CROSSLEY FARM SITE
CROSSLEY FARMS FS

ARAR OR TBC	RATIONALE FOR USE AT SITE
Safe Drinking Water Act (SDWA) – Maximum Contaminant Levels (MCLs) (40 CFR 141)	Maximum Contaminant Levels have been promulgated for a number of organic and inorganic contaminants to regulate the concentration of these compounds in public drinking water. MCLs are relevant to groundwater at the site as it is currently used as a drinking water acquifer.
Clean Water Act – Ambient Water Quality Criteria (AWQC)	Ambient water quality criteria are TBCs (i.e., non-promulgated) that have been developed for carcinogenic and non-carcinogenic compounds for the protection of human health and aquatic life. AWQC may be used to assess need for remediation of discharges to surface water or to use as benchmarks during long-term monitoring at the site.
Commonwealth of Pennsylvania Water Quality Standards (25 PA Code 93)	Surface water quality standards promulgated for protection of human health and aquatic life. These may be used to assess need for remediation of discharges to surface water or to use as benchmarks during long-term monitoring.
Commonwealth of Pennsylvania Water Quality Toxics Management Strategy (25 PA Code 16)	Water quality criteria for various toxic substances promulgated for protection of human health and aquatic life. These may be used to assess need for remediation of discharges to surface water or to use as benchmarks during long-tem monitoring.
Commonwealth of Pennsylvania Land Recycling Program (i.e., Act II) (25 PA Code 250)	Medium-Specific Concentrations (MSCs) for inorganic and organic substances in groundwater and soil promulgated for site remediation.
EPA Groundwater Protection Strategy (EPA, 1984)	Guidance on determining the classification and restoration goals for groundwater based on its value and vulnerability to contamination.
USEPA Region III Risk-Based Concentrations (RBCs)	TBCs for soil and tap water that may be used for selecting contaminants for risk assessment and/or fate and transport modeling.
EPA Soil Screening Levels (SSLs) Guidance and Generic Levels	Guidance that provides a methodology to calculate risk-based, site-specific soil screening levels (SSLs) for contaminants in soil that may be used to identify areas needing further investigation. Also provides generic SSLs for a number of contaminants in soil.
Clean Air Act (42 CFR 85) of 1970	Promulgated national primary and secondary ambient air quality standards for air pollutants for protection of public health. May be applicable in design of treatment processes.
Pennsylvania Air Pollution Control Act (25 PA Code 131) of 1971	Ambient Air Quality Standards for discharges of air pollutants. Potentially applicable to remedial design and implementation.
Pennsylvania Safe Drinking Water (25 PA Code 109)	Potentially applicable to site groundwater that is used as drinking water source.

TABLE 2-2
SUMMARY OF LOCATION-SPECIFIC ARARs AND TBCs FOR POTENTIAL USE AT THE CROSSLEY FARM SITE
CROSSLEY FARMS FS

ARAR OR TBC	RATIONALE FOR USE AT SITE
Protection of Wetlands and Floodplains (Executive Orders 11990 and 11988)	Potentially applicable to any remedial actions conducted within wetlands and/or floodplains.
Federal Water Pollution Control Act (40 CFR 116.3) (33 USC 26)	Potentially applicable to any discharges at the site
Fish and Wildlife Coordination Act (16 USC 661)	Potentially applicable if surface water is diverted or disturbed during remedial actions.
Fish and Wildlife Improvement Act of 1978 (16 USC 742)	This Act protects fish and wildlife against impacts that may affect their protected habitats. May be potentially applicable for discharge of treated water or remedial alternatives for surface water or sediment.
Fish and Wildlife Conservation Act of 1980 (16 USC 2901)	May be potentially applicable for discharge of treated water or remedial alternatives for surface water or sediments.
Endangered Species Act of 1973 (50 CFR Part 200)	Potentially applicable if any endangered or threatened species or habitats are present where remediation activities may occur.
National Historic Preservation Act of 1966 (16 USC 470 et. seq.)	Action will be taken to recover and to preserve historic artifacts that may be threatened as the result of land alteration. Potentially applicable if, historic artifacts are encountered during active site remediation activities.
National Archeological and Historic Preservation Act of 1974 (132 CFR 229)	Action will be taken to recover and to preserve scientific, prehistoric, historic, or archaeological artifacts that may be threatened as the result of land alteration. Potentially applicable if artifacts are encountered during active site remediation activities.
Delaware River Basin Commission-Ground Water Protected Area Regulations, Southeastern Pennsylvania (Resolution No. 80-18)	Regulations to assure the effective management of water withdrawals to avoid depletion of natural stream flows and ground waters and to protect the quality of such water.

TABLE 2-3
SUMMARY OF ACTION-SPECIFIC ARARs AND TBCs FOR
POTENTIAL USE AT THE CROSSLEY FARM SITE
CROSSLEY FARMS FS

ARAR OR TBC	RATIONALE FOR USE AT SITE
Resource Conservation and Recovery Act (RCRA) – Hazardous Waste Generator and Transporter Requirements (40 CFR Parts 262 and 263)	Establishes responsibilities of generators and transporters of hazardous waste in the handling, transportation and management of waste. Potentially applicable for disposal of sediments or wastes produced by groundwater treatment processes.
Department of Transportation (DOT) – Hazardous Materials Transport (49 CFR Parts 107 and 171-179)	Regulations for the transportation of hazardous materials including packaging, marking, labeling and transportation methods. Off-site shipments of any contaminated materials (i.e., sediments, spent carbon canisters) from the site would have to comply with these regulations.
Clean Water Act – Natural Pollutant Discharge Elimination System (NPDES)	These requirements are potentially applicable to any alternatives that include a water discharge.
National Environmental Policy Act of 1970 (NEPA) (42 USC 4321)	Requires federal agencies to evaluate the environmental impacts associated with major actions that they fund, support, permit, or implement. Alternatives could constitute significant activities, thereby making NEPA requirements ARARs.
Occupational Health and Safety Act (29 USC 651-678) of 1970	Regulates worker health and safety during implementation of remedial actions. Applicable to any investigative or remedial tasks conducted at the Site.
Pennsylvania National Pollutant Discharge Elimination System (25 PA Code 92)	Potentially applicable to any remedial actions that would involve discharge of water.
Pennsylvania Stormwater Management Act of 1978 (Act No. 167)	Requires the implementation of measures to control stormwater runoff. Potentially applicable for certain remedial activities.
Pennsylvania Erosion Control Regulations (25 PA Code 102)	Requires the implementation of measures to control erosion and stormwater runoff. Potentially applicable for certain remedial activities.
Pennsylvania Drilling Water Wells (17 PA Code 47)	Requirements for the installation and construction of groundwater wells. Potentially applicable for alternatives involving well installation.
Pennsylvania Hazardous Substances Transportation Regulations (PA Code, Title 13 and 15)	Regulations that govern the transport of flammable liquids and solids, oxidizing materials, poisons and corrosive liquids. Potentially applicable to any off-site shipments of hazardous materials.

chemical or a close related group of chemicals. These requirements do not consider the mixture of chemicals. Typical chemical-specific ARARs are federal and state drinking water standards.

2.2.1.2 Location-Specific ARARs and TBCs

Location-specific ARARs are restrictions placed on the concentrations of hazardous substances or the conduct of activities solely because the substances or activities are in specific areas. The general types of location-specific ARARs include federal and state regulations that govern activities in wetlands and flood plains that may result in their degradation or impairment of their functions, regulations promulgated to protect wildlife and endangered species, and regulations that are protective of historic or archeological artifacts.

2.2.1.3 Action-Specific ARARs and TBCs

Action-specific ARARs are usually technology-or activity-based requirements or limitations on actions taken with respect to hazardous wastes. These requirements are generally focused on actions taken to remediate, handle, treat, transport, or dispose of hazardous wastes. These action-specific requirements do not in themselves determine the remedial alternative; rather, they indicate how a selected alternative must be achieved.

2.3 IDENTIFICATION OF CHEMICALS OF CONCERN AND MEDIA FOR REMEDIATION

Based on the human health and ecological risk assessments conducted as part of the investigation activities on and adjacent to the Crossley Farm Site, chemicals of concern (COCs) and their respective media were identified. Table 2-4 details the carcinogenic and non-carcinogenic chemicals of potential concern (COPCs) that were identified for groundwater, residential wells, and sediment and soil at the Crossley Farm. The list of COPCs do not include compounds for which the calculated carcinogenic risk fell within EPA's target risk range of 1×10^4 to 1×10^6. No exposure pathways for surface water or soil resulted in unacceptable carcinogenic or non-carcinogenic risk levels. One COPC was identified for sediment based on the human health risk assessment. Based on the RI sampling, the RI concluded that the Cr present in sediment sample SD-2 is not related to the disposal of hazardous wastes at the Crossley Farm Site. Therefore, sediment will not address as a media of concern in this FS.

COCs for site groundwater and the residential wells were determined based on a screening of the detected maximum concentrations with Federal criteria (i.e., MCLs) and background

TABLE 2-4
CHEMICALS OF POTENTIAL CONCERN (COPCs)
CROSSLEY FARM FS

	MEDIA		
Compound	Groundwater	Residential Wells (1)	Sediment
Nickel		•	
Iron		•	
Thallium		•	
Chromium		•	•
Copper		•	
Zinc		•	
Benzene	•		
Carbon Tetrachloride	•		
Chloroform	•		
1,1-Dichloroethene	•		
1,2-Dichloroethane	•		
Tetrachloroethene (PCE)	•	•	
Trichloroethene (TCE)	•	•	
1,1,2-Trichloroethane	•		
Cis-1,2-Dichloroethene		•	

(1) The risk analysis for residential wells (TtNUS, 2000) was calculated on an individual well basis, therefore the COCs listed above may not be for all wells.

concentrations. The COC list was developed by comparing the maximum concentrations to U.S. EPA's current Drinking Water Standards (EPA, 1998) and PADEP Medium Specific Concentrations (MSCs) for groundwater (i.e., used aquifers). Based on this comparison, Table 2-5 outlines the final COCs for site groundwater and residential wells. The COCs for residential wells are based on the results of a risk assessment conducted on untreated residential well samples. EPA's interim ROD for OU-1 however, requires the use of point-of-entry treatment systems, which are currently in operation at the affected residences. Therefore, this FS will not address residential wells as a media or concern of the selected remedy for OU-1

2.4 PRELIMINARY REMEDIATION GOALS

Preliminary remediation goals (PRGs) are medium-specific concentration values for contaminants that are protective of human health and the environment if present in groundwater, surface water, sediment, or soil. Remediation goals that establish acceptable contaminant levels or ranges of levels that must be achieved under the remedial action are ultimately chosen from the range of PRGs when the remedy is selected. For purposes of the FS, PRGs were determined for area groundwater based on the following criteria:

- Protection of human health from exposure to contaminants in groundwater.
- Restore the aquifer to meet Federal MCLs.
- Comply with ARARs and TBCs to the extent practicable.

Additionally, background concentrations of COCs and analytical detection limits were identified as potential PRGs to ensure selection of clean-up goals that are reasonably attainable and measurable. As groundwater from the site is used as a potable water supply, the PRGs include concentration values for contaminants present in the groundwater that would be protective of human health if that water were used for the typical residential uses of ingestion, bathing, and showering. Table 2-6 details the potential PRGs for the COCs identified for site groundwater.

2.5 METHOD USED FOR DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES (RAOs)

The development of the medium-specific RAOs for a site is typically based on the risks posed by site-related contaminants to human and ecological receptors, threats of continued degradation of environmental media and comparison of detected contaminant levels with available regulatory standards. Generally, human health RAOs are formulated to prevent exposures to site-related contaminants that result in excess carcinogenic and non-carcinogenic health risks or to contaminants that exceed regulatory requirements (e.g., MCLs).

TABLE 2-5
CHEMICALS OF CONCERN (COCs)
CROSSLEY FARM FS

Compound	MEDIA Groundwater	 Residential Wells
1,2-Dichloroethane		•
Tetrachloroethene (PCE)	•	•
Trichloroethene (TCE)	•	•
Chromium		•
Copper		•
Iron		•
Nickel		•
Thallium		•
Zinc		•

Note: Shading denotes media of concern and compounds to be addressed in this FS.

TABLE 2-6
PRELIMINARY REMEDIATION GOALS FOR
AREA GROUNDWATER
CROSSLEY FARM SITE
HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

Site Specific COC	Range of Positive Detection[1]			Maximum Background[1]	CRDL[1]	Federal SDWA[1]	PADEP MSC[1]	RBC SCREENING VALUES[1]
	Min		Max					
Chromium	1	-	910	1.3	10	100 (MCL)	180 (G)	110
Copper	3.1	-	4170	595	25	1000 (S)	1000 (MCL)	1500
Iron	12	-	411000	11200	100	300 (S)	-	11000
Nickel	0.7	-	466	3.5	40	100 (MCL)	100 (H)	730
Thallium	2.3	-	14.2	-	10	2 (MCL)	2 (MCL)	2.6
Zinc	13.2	-	4890	4890	20	5000 (S)	2000 (H)	11000
1,2-Dichloroethene (cis)	0.08	-	270	NA	10	70 (MCL)	70 (MCL)	61
Tetrachloroethene	0.06	-	150	NA	10	5 (MCL)	5 (MCL)	1.1
Trichloroethene	0.07	-	3800	NA	10	5 (MCL)	5 (MCL)	1.6

(1) Units are ug/L

COC - Chemical of Concern
CRDL – Contract Required Detection Limit
SDWA - Safe Drinking Water Act
S - Secondary Drinking Water Criteria
MCL - EPA Maximum Containment Level
MSC – Medium Specific Concentration - PADEP Land Recycling Program, Subchapter C, Sections 250.304 and 250.305, for used aquifers, TDS <=2500, residential
G - Ingestion
H - Lifetime Health Advisory Level
N - Inhalation
RBC - Risk Based Concentration for Tap Water, EPA Region III
NA - Not Applicable

2.5.1 Statement of Remedial Action Objectives

Site specific remedial action objectives specify COCs, media of interest, exposure pathways, and cleanup goals or acceptable contaminant concentrations. Remedial action objectives may be developed to permit consideration of a range of treatment and containment alternatives. The FS addresses contaminated groundwater. Based on the current data, remediation of surface water, sediments and soils is not warranted. Residential drinking wells are currently addressed by the ROD for OU-1. To protect the public and environment from potential current and future health risks, the following remedial action objectives have been developed:

- Limit future migration from the site of contaminated groundwater that presents an unacceptable risk.

2.6 GENERAL RESPONSE ACTIONS AND ACTION-SPECIFIC ARARS

General Response Actions (GRAs) are broadly defined remedial approaches that may be used, by themselves or in combination with one or more of the others, to attain the RAOs. Action-specific ARARs and TBCs are those regulations, criteria, and guidances that must be complied with or taken into consideration during remedial activities on site.

2.6.1 General Response Actions

GRAs describe categories of actions that could be implemented to satisfy or address a component of a remedial action objective for the site. The remedial action alternatives will then be composed using general response actions singly or in combination to meet the remedial action objectives. The remedial action alternatives, composed of GRAs, will be capable of achieving the remedial action objective.

The following general response actions will be considered:

- No Action
- Limited Action (Institutional Controls, Monitoring, Natural Attenuation)
- Containment
- In Situ Treatment
- Ex Situ Treatment
- Disposal (off-site)

3

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

The identification, screening, and evaluation of potentially applicable technologies and process options are steps in the FS development. The primary objective of this phase of the FS is to develop an appropriate range of remedial technologies and process options that will be formulated into preliminary alternatives applicable to remediation of the contaminants and media associated with the site. This initial effort involves the identification of demonstrated and emerging or experimental technologies and screening to eliminate those technologies that are ineffective or not technically feasible to implement for the given site conditions.

Using the set of general response actions developed to address the RAO, potential remedial technologies and process options were identified and screened according to their overall technical implementability to the media of concern, primary contaminants (VOCs and metals), and site-specific conditions. The purpose of this screening was to investigate the spectrum of demonstrated and emerging technologies and process options and to eliminate those obviously not applicable or responsive to the site characteristics and constraints, the proposed RAO, and the general response actions. The selection of technologies and process options for initial screening was based on the "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" (U.S. EPA, 1988). The screening is conducted in several steps, first at a preliminary level to focus on relevant technologies and process options. Second, the screening is conducted at a more detailed level based on several evaluation criteria. Thirdly, process options are selected to represent the technologies that were not eliminated in the second step.

The evaluation criteria for detailed screening of technologies and process options that have been retained after the preliminary screening are effectiveness, implementability, and cost. Descriptions of each of these criteria are as follows:

- Effectiveness
  - Protective of human health and the environment; reduces toxicity, mobility, or volume; and is a permanent solution.
  - Ability of the technology to address the estimated areas or volumes of contaminated medium.
  - Ability of the technology to meet the remediation goals identified in the remedial action objectives.
  - Technical reliability (proven and demonstrated versus innovative) with respect to contaminants and site conditions.

- Implementability
  - Overall technical feasibility at the site.

- Availability of vendors, mobile units, and storage and disposal services.
- Administrative or institutional feasibility (permitting requirements).
- Special long-term maintenance and operation requirements.

- Cost (Qualitative)
  - Capital cost.
  - Operation and maintenance (O&M) costs.

Technologies and process options will be identified in the following sections for the remediation of groundwater and sediment.

3.1 PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

This section identifies and screens technologies and process options for the media of concern (i.e., groundwater) at a preliminary stage based on implementation with respect to site conditions and contaminants of concern. Table 3-1 summarizes the preliminary screening of technologies for remediation of groundwater by presenting the general response actions, identifying the technologies and process options, providing a brief description of each technology and/or process option followed by the screening comments. At this stage of the FS process, the screening evaluations generally focus on effectiveness and implementability, with less emphasis on cost evaluations. No technologies are eliminated based on cost alone. However, technologies or process options of equal effectiveness will be screened to identify the lowest cost option for further evaluation. Many of the technologies presented would not be implemented alone; instead, they will most likely be combined with other technologies into remedial action alternatives.

3.2 GROUNDWATER REMEDIAL TECHNOLOGY SCREENING

3.2.1 No Action

The NCP, per 40 CFR 300.430, requires that a No Action scenario be considered in order to provide a baseline level to which other remedial technologies and alternatives can be compared. Under the No Action scenario, no measures will be taken to contain or remediate the groundwater beneath and downgradient of the site. There would be no reduction in potential human exposure to contaminated groundwater.

TABLE 3-1
PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
FOR CONTAMINATED GROUNDWATER
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

General Response Action	Technology	Process Options	Description	Screening Comment
No Action	None	Not Applicable	No remedial activities conducted to address contamination. Long-term monitoring program to monitor groundwater levels.	*Retained for baseline comparison purposes* in accordance with NCP 40CFR Section 300.430(e).
Limited Action	Institutional Controls	Deed Restrictions and Notices	Administrative action used to restrict future and current activities at site and at individual properties. Installation of private wells and use of untreated groundwater in the area of contamination may be restricted using property deeds.	Retain
	Institutional Controls	Local Ordinances	Administrative actions enacted by municipalities to limit property use or activities and installation of water supply wells.	Eliminate-Significant portion of plume off-site; difficult to implement and enforce. Deed restrictions and notices provide same level of protection
	Monitoring	Sampling and Analysis of Groundwater and Residential Water	Periodic sampling and analysis of groundwater and other media to assess extent and nature of contaminant plume.	Retain
	Natural Attenuation	Naturally-occurring biodegradation and dilution	Monitoring of groundwater to assess contaminant dilution or degradation.	Eliminate - Length of time required to attain MCL levels in dissolved and residual plumes is expected to be very long and impact to a number of private wells is documented.

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TABLE 3-1
PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR CONTAMINATED GROUNWATER
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

General Response Action	Technology	Process Options	Description	Screening Comment
Containment	Vertical Barriers	Slurry Wall	Low-permeability subsurface wall used to restrict horizontal migration of contaminants and groundwater.	Eliminate – Dissolved contaminant plume is too large and groundwater contamination in residual zone extends beyond conventional equipment depth (>100 feet).
		Grout Curtain	Pressure injection of low permeability grout to form a continuous subsurface wall to restrict horizontal migration of groundwater.	Eliminate – Dissolved contaminant plume is too large and groundwater contamination in residual zone extends beyond conventional equipment depth where the installation would be impractical.
		Sheet Piling	Metal sheet piling driven into the ground to restrict horizontal migration of groundwater.	Eliminate – Dissolved contaminant plume is too large and groundwater contamination in residual zone extends beyond conventional equipment depth where the installation would be too expensive and impractical.
		Hydraulic Barrier	Use of injection/extraction wells within or around the contaminant plume to restrict horizontal migration of groundwater.	Retain use of extraction wells within/around the contaminant plume to restrict migration.
	Horizontal Barriers	Physical Barrier	Injection of bottom sealing slurry beneath source to minimize vertical migration of groundwater.	Eliminate - source of contamination removed during Summer 1998. Depth of highest groundwater contaminant levels beyond practical installation limits.
Removal	Groundwater Extraction	Extraction Wells	Series of conventional pumping wells used to remove contaminated groundwater.	Retain use of extraction wells within/around a portion of the dissolved contaminant plume and residual zone to withdraw groundwater.

General Response Action	Technology	Process Options	Description	Screening Comment
		Collection Trench	A permeable trench used to intercept and collect groundwater.	Eliminate - groundwater contamination in residual zone extends to a depth beyond where the installation of such trenches would be practical. Extent of dissolved plume is too large.
		Anaerobic	Enhancement of biodegradation of organics in an anaerobic (oxygen-deficient) environment by addition of hydrogen release compounds (HRCs).	Eliminate – No proven large-scale studies for chlorinated organics have been conducted; full-scale use discouraged due to possible formation of more toxic substances.
	Physical/Chemical	Air Sparging/ Vapor Extraction (AS/VE)	Volatilization of organics by injection of air in the groundwater and vacuum-extraction and treatment of volatilized compounds.	Retain for treatment of higher contaminant concentrations in residual zone or isolated areas in dissolved plume.
		Permeable Reactive Barriers (PRBs)	Use of permeable barriers filled with a reactive medium (zero-valent iron) which allow the passage of groundwater and reacts with the contaminants.	Eliminate – Dissolved contaminant plume is too large and groundwater contamination in residual zone extends to a depth beyond conventional equipment limits. May also produce levels of other compounds which effects groundwater quality.
		Dynamic Underground Stripping	Vaporization of organics by injection of steam in the groundwater and vacuum-extraction and treatment of volatilized compounds.	Eliminate – only applicable to area of extremely high contaminant concentrations (DNAPL) which has not been fully characterized.

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TABLE 3-1
PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
FOR CONTAMINATED GROUNWATER
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

General Response Action	Technology	Process Options	Description	Screening Comment
In-situ Treatment (Continued)	Physical/Chemical (Continued)	Chemical Oxidation	Degradation of organic contaminants by addition of strong oxidizing agents, including hydrogen peroxide and potassium permanganate.	Retain for treatment of higher contaminant concentrations in residual zone or isolated areas in dissolved plume.
Ex-situ Treatment	Physical	Air Stripping	Contact of water with air to remove volatile organics.	Retain for removal of VOCs from dissolved and residual groundwater plumes.
		Granular Activated Carbon (GAC) Adsorption	Removal of contaminants via vapor- or liquid-phase adsorption onto granular activated carbon.	Retain for removal of a wide range of organics from dissolved and residual groundwater plumes.
		Sedimentation	Separation of solids from water via gravity settling.	Retain as a pretreatment step prior to certain organics removal processes and as a means of dewatering treatment residues.
		Filtration	Separation of suspended solids from water via entrapment in a bed of granular media or membrane.	Retain as a pretreatment step prior to certain organic removal processes and as a means of dewatering treatment residues.
		Equalization	Providing a "wide-spot" in the treatment train to accommodate surges in flow and blend multiple streams of different composition.	Retain as a pre-treatment step.
	Chemical	Oxidation	Use of oxidizers such as air, ozone, peroxide, chlorine, or permanganate to oxidize and precipitate inorganic compounds.	Eliminate - Air stripping and carbon adsorption more effective and fewer operational problems.
		Enhanced Oxidation	Use of oxidizers in combination with UV radiation to oxidize and destroy organic compounds.	Eliminate - Air stripping more effective, poses fewer operational problems and is more cost effective.

TAbLE 3-1
PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
FOR CONTAMINATED GROUNWATER
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA
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General Response Action	Technology	Process Options	Description	Screening Comment
Ex-situ Treatment (continued)	Chemical (continued)	Ion Exchange	Process in which ions, held by electrostatic forces to charged functional groups on the resin surface, are exchanged for ions of similar charge in a water stream.	Eliminate – Mostly applicable to removal of dissolved inorganic compounds.
		Coagulation/ Flocculation	Use of chemicals to neutralize surface charges and promote attraction of colloidal particles to facilitate settling.	Retain as a pretreatment step prior to certain organics removal processes.
		Neutralization/pH Adjustment	Use of acids or bases to counteract excess pHs.	Retain as a possible pretreatment step or final step prior to discharge.
	Biological	Aerobic	Degradation of organic contaminants by a culture of microorganisms in an aerobic (oxygen-rich) environment.	Eliminate – Aerobic biodegradation of the high concentrations (30,000+ µg/L) of TCE is unproven and unlikely.
		Anaerobic	Degradation of organic contaminants by a culture of microorganisms in an anaerobic (oxygen-deficient) environment.	Eliminate – Anaerobic biodegradation of the high concentrations of TCE and PCE is unproven and could lead to formation of a more toxic chemical (vinyl chloride).
Disposal	On-Site Discharge	Reinjection	Use of injection wells, spray irrigation, or infiltration to discharge collected/treated groundwater underground.	Retain
	Off-Site Discharge	Treatment Facility	Treatment and disposal of water at an offsite treatment works.	Eliminate – No offsite treatment facility within reasonable distance.

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Effectiveness

The No Action option would not meet the remedial action objectives as stated in Section 2.0. Human health risks associated with exposure to carcinogenic and non-carcinogenic contaminants in site groundwater would remain. Risks associated with exposure to carcinogenic and non-carcinogenic contaminants in groundwater used as residential drinking water would continue over time as a result of continued use of contaminated groundwater that migrates from the site.

Implementability

There are no implementability considerations with the No Action scenario.

Costs

There would be no capital costs associated with the No Action scenario because no actions other than the 5-year review of site status would be conducted.

Conclusion

The No Action scenario is retained for groundwater for baseline comparison purposes as required by the NCP.

3.2.2 Limited Action

Institutional Controls

Institutional controls are actions that do not involve engineering actions or treatments to reduce potential health threats or remediate contaminant sources or plumes. These controls can include such options as deed restrictions and notices, local ordinances, access restrictions, and monitoring. Under institutional controls, no active removal or treatment of contaminated groundwater is conducted to reduce or prevent potential human exposure.

3.2.2.1 Deed Restrictions and Notices

Restrictions are placed on property deeds to restrict or limit future site activities to prevent human contact with contaminated groundwater. Deed restrictions that may be used include restrictions on types of development allowed (i.e., no residential use) or limitations on use of groundwater without prior treatment.

Deed notices are the placement and incorporation of language into a property deed to inform prospective purchasers of any contamination present at the property.

Effectiveness

Deed restrictions could be applied to limit future land use activities that would result in potential exposures. Historically, these restrictions and/or notices by themselves have not proven to be reliable and are difficult to enforce. Deed restrictions and notices alone are not effective in the long term to reduce risk and would not achieve the RAO. There are no potential impacts to human health or the environment through the implementation of deed restrictions or notices.

Implementability

Deed restrictions may be implemented by the property owners or by state and local authorities. As each property belongs to a different owner and because owners may be reluctant, attaching restrictions and notices to deeds may be difficult. The state and local authorities may have to go through arduous administrative procedures to impose restrictions and notices on deeds. Deed restrictions and notices are typically difficult to implement and to enforce.

Costs

Deed restrictions and notices require limited administrative actions and would result in low capital costs. Long-term O&M costs would be minimal.

Conclusion

Deed restrictions are likely to be difficult to implement and to enforce. Although deed restrictions and notices would be expensive to implement, they may directly or indirectly decrease value of properties impacted by the site or located near the site. Deed restrictions and notices are generally ineffective measures in preventing the use of contaminated groundwater, however they do provide notification to prospective property buyers, but require updating as necessary. However, deed restrictions and/or notices are retained for groundwater to be used in combination with other process options for the development of remedial alternatives.

3.2.2.2 Local Ordinances

Local ordinances are administrative actions enacted by municipalities to limit property use or activities. Local ordinances used to reduce exposure to contaminated media may include zoning laws and Board of Health regulations that limit private well installation or use of groundwater without treatment. Local ordinances can restrict certain activities related to surface water bodies fed by contaminated groundwater (i.e., swimming, fishing).

Effectiveness

Local ordinances may reduce the exposure to contaminated groundwater by controlling the installation of new wells or use of contaminated groundwater. In addition, ordinances can restrict activities at publicly owned surface water locations, thereby reducing exposure. Effectiveness of ordinances is highly dependent on enforcement by local authorities and compliance by the public. For the same reasons cited for deed restrictions, residents may still use untreated groundwater and be exposed. There are no potential impacts to human health or the environment through the implementation of local ordinances.

Implementability

Although enforcement may be possible, it would probably be difficult because this type of ordinance would be disruptive on residences. The RAO to protect human health would likely not be achieved by local ordinances. Local ordinances may be viable, if enforced, as a means of limiting exposure to contaminated groundwater.

Costs

The development of ordinances is generally low in cost. The implementation of any ordinances would result in moderate costs due to labor and length of enforcement period required.

Conclusion

Local ordinances may provide some protection of human health if they can be enforced, however, they may be difficult to develop and implement. As deed restrictions/notices will provide basically the same level of protection, local ordinances will not be retained for development of remedial alternatives.

3.2.2.3 Groundwater Monitoring

Groundwater (including residential well water) and surface water throughout the contaminant plume would be sampled and analyzed on a periodic basis to monitor contaminant levels and distribution in groundwater beneath and downgradient of the site and in on-site and off-site surface waters. The data would be used to evaluate the migration of contaminants and quality of impacted private wells. Monitoring could also be used to monitor potential natural contaminant degradation or the progress of active groundwater remediation. Monitoring would not limit exposure to contaminants, however, it could limit potential future exposure by serving as an early warning mechanism.

Effectiveness

Monitoring would not reduce the toxicity, mobility, or volume of contaminants in groundwater or surface water, but it would allow for the evaluation of off-site migration of contaminants and the potential reduction in contaminant concentrations through natural contaminant degradation. By serving as a warning mechanism, periodic monitoring would enable users to either discontinue use of groundwater or take appropriate corrective measures if a threat of contamination arose in the area.

Implementability

A monitoring program could be readily implemented since sampling and laboratory analysis techniques are routine actions. Local and state permits would be required for monitoring well installation, if additional wells were necessary.

Costs

Capital costs would be incurred only if additional monitoring wells were installed. Operation and maintenance costs are generally low, but could be substantial if numerous on-site and private wells need to be monitored for a long time period.

Conclusion

Monitoring by itself would not achieve any of the remedial action objectives for groundwater. However, in combination with other process options, it is a viable means of assessing the impact of remedial measures on the contaminant levels and extent in groundwater, surface water and residential wells. Monitoring will be retained for the development of remedial alternatives for groundwater.

3.2.2.4 Natural Attentuation

Natural Attentuation would consist of monitoring groundwater and drinking water quality to determine the extent to which indigenous microorganisms and natural biodegradation processes would break down chlorinated VOCs over time. For this purpose, groundwater samples would be regularly collected and analyzed for natural attentuation parameters. These parameters include oxidation/reduction potential indicator (ORP), dissolved oxygen (DO), pH, alkalinity, temperature, conductivity, biochemical and chemical oxygen demand (BOD and COD), total organic carbon (TOC), ferrous and total iron, sulfur compounds (sulfates, sulfides), nitrogen compounds (nitrates, nitrites), phosphates, chlorides, and metabolic gases (methane, ethane, ethene, and carbon dioxide) (NJWEA, 1998).

Effectiveness

Natural Attentuation would be expected to reduce contaminant concentrations in the aquifer. However, the reduction process would be slow, especially for chlorinated VOCs like TCE, and potential human risks due to injestion of untreated groundwater would remain until concentrations are sufficiently reduced. In addition, migration of contaminants off-site would continue. Hydrologic and geochemical processes within the contaminated aquifer may change over time, possibly reducing the conditions that are amendable to Natural Attentuation.

Implementability

Natural Attentuation would be easy to implement. Monitoring of groundwater quality and biodegradation rates, groundwater use or pre-treatment restrictions, and periodic site reviews could readily be preformed and the necessary resources are available to provide these services.

Costs

Capital and O&M costs for Natural Attentuation would be relatively low.

Conclusion

Due to the extent of the dissolved plume (>60 acres), documented impact at a number of private wells, and the concentration levels of TCE and PCE in the residual zone, natural attentuation is eliminated from further consideration. The low probility of effectiveness and the length of time that would be required to attain, if possible, the MCLs are also factors contributing to the elimination of this technology.

3.2.3 Containment

A number of physical and hydraulic methods for plume containment are available, including vertical and horizontal barriers and groundwater pumping/extraction. Vertical barriers include slurry walls, grout curtains, and sheet piling. Injection of a bottom sealing slurry beneath a source area to reduce and/or eliminate the vertical migration of contaminants is a type of horizontal barrier that is used when the depth of the source is known.

As noted in the RI Report, the site is geologically underlain by weathered hornblende gneiss and some granite gneiss. The saprolite and bedrock materials are variable in the frequency of fractures, however fractures, when present, are the predominant avenues for groundwater flow. Based on the historical monitoring data, TCE concentrations significantly increase with depth beneath the former borrow pit, suggesting the possible presence of DNAPL. To date, the sampling data has not resulted in the determination of the vertical extent of contamination beneath and immediately downgradient of the borrow pit. Monitoring wells constructed in the borrow pit area (HN-19, HN-20, HN-23, and HN-01) range in depth from 73.5 feet to 259 feet.

Due to the fractured nature of the saprolite and bedrock materials and the depth of occurrence of significant concentration levels (i.e., >100 feet) the only technology which will be considered for groundwater containment is hydraulic extraction within the contaminant plumes. Hydraulic groundwater containment uses a pumping system, composed of a series of wells that are used to intercept groundwater and reduce its rate of migration. The wells used in the capture system are designed and located to provide optimum efficiency in reducing the hydraulic gradient within the plume of contamination. Horizontal barriers would not be applicable as the source of the contamination (i.e., drums) has been removed. Extraction of the contaminated groundwater may also result in the capture or decrease in flow of water at certain on-site springs or surface water locations and certain residential wells. Spring locations that would be expected to be impacted by a containment system are no. 11, no. 13 and no. 14.

Effectiveness

Extraction is a demonstrated and proven technology for the containment of contaminated groundwater plumes. Typically this technology is combined with treatment processes prior to the extracted groundwater being discharged to the environment. Other applications have been the recirculation of untreated water through the contained aquifer. The effectiveness of a well system for contaminant containment depends largely on site-specific conditions and knowledge regarding the horizontal and vertical extent of the contaminant plume. The fractured saprolite and bedrock systems beneath the site could impact the effectiveness of an extraction well system; however, the off-site flow of contaminated water should be decreased. Additional field data on the vertical extent of the intermediate and deep plumes would be necessary. The size of the TCE and PCE plumes may also impact the effectiveness of a groundwater extraction alternative. The placement of a containment and/or extraction system should be designed to provide the greatest impact on elevated concentrations. In addition, for containment of the 100+ ug/L TCE plume in the intermediate and deep aquifers, additional information regarding the horizontal extent must be obtained. The placement of the containment well network would likely impact the flow at certain on-site springs. Based on the RI sampling data, it can be concluded that groundwater from beneath the former drum disposal area flows west-southwest and is the source for surface water sample location no. 11. The placement of wells to contain the cis-1,2-dichloroethene plume that begins beneath the drum disposal area would impact the surface water flow at this location. This technology is reliable and poses minimal effects on human health and the environment during implementation.

Implementability

Containment of the residual plume (i.e., hot spot or DNAPL) through a pumping well network could be implemented on a portion of the site. Additional information regarding the vertical extent of the residual zone would be needed to design an effective system. The technology uses readily available equipment and techniques and has been widely used in similar situations. Implementation of this technology would require long term operation and maintenance. Maintenance would require periodic replacement of mechanical components and well inspections. Local and state permits would be required for installation of the extraction wells and the discharge of the treated water.

Due to the extent of the dissolved plume, an evaluation would be needed to determine what contaminant concentration levels would be contained. Immediately downgradient of the former borrow pit, TCE concentrations in the intermediate aquifer (well depth 100 feet to 130 feet) range from 24,000 ug/L to 190,000 ug/L. PCE concentrations range from 1,100 ug/L to 6,000 ug/L. The areal extent of the TCE plume with concentrations in the 1,000 ug/L range is approximately 17.8 acres for the shallow aquifer and 60.8 acres for the intermediate aquifer. For the dissolved TCE plume with concentrations in the 100 to 999 ug/L range, the areal extent of the shallow aquifer plume is approximately 68.4 acres; the areal extent of the intermediate dissolved plume has not been delineated, but is significantly more extensive than the shallow plume. While recovery of contaminated groundwater from the 1,000+ ug/L and 10,000+ ug/L plumes may be implementable with a reasonable number of wells, the containment of the 100+ ug/L plume would require a very large number of wells, and extensive collection piping and pumping stations systems, both onsite and offsite. Access agreements would need to be obtained from a number of property owners to allow for the containment of the 100+ ug/L dissolved TCE plume and would impact the supply of water to these residences.

Costs

Capital and O&M costs for groundwater containment via pumping/extraction would be moderate to high, depending on the extent of the contaminant plume to be remediated.

Conclusion

Although there are some concerns about effectiveness, implementability, and impact to residential water supplies, groundwater extraction for plume containment is retained in combination with other process options for the development of remedial alternatives.

3.2.4 Removal

Groundwater removal, combined with ex-situ treatment technologies may be an applicable technology for a portion of the plume under this General Response Action. For removal purposes, groundwater extraction uses a pumping system composed of a series of wells which are used to intercept contaminated groundwater but the objective of this interception is capture and removal for treatment rather than migration restriction. The wells used in the capture system are designed and located to provide optimum efficiency in capturing contaminated groundwater while minimizing the collection of uncontaminated groundwater. Groundwater extraction may also be achieved utilizing a trench or series of trenches to capture contaminated groundwater.

Effectiveness

Groundwater extraction is an established and proven technology for the removal of contaminated groundwater. This technology is reliable and has minimal effects, if any, on human health and the environment during its implementation. While the initial effectiveness of this technology is high, it has often been shown to decrease over time due to contaminant dispersion. The effectiveness of an extraction well system or trench system depends largely on the extent of contamination and site specific geology and hydrogeology. With the collection of additional field data regarding the vertical extent of groundwater contamination, extraction wells should be effective for the long-term capture of groundwater within the dissolved TCE plume. Extraction, however may not completely remove the DNAPL source zone due to the fractured bedrock and unknown depth of contamination beneath the borrow pit. The use of an extraction trench system filled with a porous medium, however, would not be effective due to the vertical extent of the residual groundwater plume.

Implementability

Groundwater removal through a pumping well system could be implemented at the site. This technology uses readily available equipment and techniques and has been widely used in similar situations. Implementation of this technology would require long term operation and maintenance. Maintenance would require periodic replacement of mechanical components and well inspections. Local and state permits would be required for installation of the extraction wells. Depending upon the extent of the dissolved contaminant plume that is targeted for recovery, the implementation of groundwater extraction/removal may require the installation and operation of wells on private properties.

Groundwater removal through a trench or series of trenches, however, would not be easily implemented at the site. A significant portion of the dissolved and residual plumes extend beyond the depth of a trench installed with conventional equipment

Costs

Capital and O&M costs for groundwater extraction would be moderate to high, depending on the extent of the contaminated plume to be remediated and the number of wells to be installed and maintained. The capital costs for installation of a trench or trench network would be moderate to high depending upon the depth and length of the trenches. Operation and maintenance costs would be expected to be low to moderate depending upon the pump sizes and required maintenance.

Conclusion

Although there are some concerns about effectiveness and implementability, groundwater extraction/removal using wells will be retained in combination with other process options for the development of remedial alternatives. Groundwater removal via a trench or trench network will not be retained due to the low possibility of being implemented.

3.2.5 <u>In Situ Treatment</u>

3.2.5.1 Air Sparging/Vapor Extraction

Air Sparging and Vapor Extraction (AS/VE) is the injection of air into the saturated groundwater zone and the extraction via a vacuum, of volatile contaminants from the porous medium in the vadose zone. Air is injected through a network of wells screened at various depths within the contaminant plume. A vacuum is applied through another network of wells screened in the vadose zone above the contaminant plume.

The extracted vapors are then collected and treated prior to venting to the atmosphere. Vapor-phase granular activated carbon (GAC) adsorption, catalytic oxidation, or thermal destruction are several of the technologies used for treatment of the vapors.

Effectiveness

AS/VE is generally an effective technology to remove dissolved VOCs from groundwater. AS/VE can also be quite effective for the in situ removal of a volatile DNAPL such as TCE, provided that the current induced by the air injection and vapor extraction can be brought in contact with the areas of DNAPL accumulation. At the Crossley Farm site, the exact location(s) of possible DNAPL accumulation has not been delineated to date, thus the effectiveness of AS/VE for the in situ removal of DNAPL would be questionable. A potential problem with many AS/VE applications is that, if the network of air injection and vapor extraction wells develops a subsurface current that is not sufficiently strong enough to volatilize the DNAPL, the current may still be strong enough to disrupt relatively static pools of the contaminants and accelerate their migration.

Implementability

AS/VE could be implemented at the Crossley Farm site but with some difficulty due to the potential depth of the contamination (i.e., greater than 400 feet). This technology uses readily available equipment and techniques and has been used at a number of chlorinated solvent contamination sites. Implementation of this technology would require long term operation and maintenance. Maintenance would require periodic replacement of mechanical components and well inspections. Local and state permits would be required for the installation of the air injection and vapor extraction wells. The areal extent of the 1,000+ ug/L plume would require the installation of a very large number of air injection and vapor extraction wells, some of which would be located on private properties. Implementation of the AS/VE technology may be more applicable for the residual (i.e., hot spot) or DNAPL zone of contamination at the Crossley Farm Site where DNAPL may be volatilized if it is directly contacted by the sparging air. Additional information would need to be collected regarding both the horizontal and vertical extent of contamination beneath the borrow pit where DNAPL is suspected to be present.

Costs

The capital and O&M costs associated with the implementation of AS/VE at the Crossley Farm Site would be expected to be medium to high because of the areal extent and depth of the contaminant plume. Installation of such a system at the site would necessitate the construction of a number of deep air injection wells, as well as large size air compressors and vacuum pumps.

Conclusion

AS/VE is retained for development of in-situ remedial alternatives for remediation of the potential DNAPL (i.e., hot spot) area of groundwater.

3.2.5.2 Chemical Oxidation

In situ chemical oxidation involves the application of a strong oxidizing agent to a contaminated groundwater zone in order to facilitate the degradation of toxic contaminants to less toxic or benign compounds. Fenton's Reagent, a solution of hydrogen peroxide and ferrous iron, and potassium permanganate have been widely used in the wastewater treatment industry for the ex situ chemical oxidation of a number of common wastewater and groundwater contaminants, including TCE. With Fenton's Reagent the iron acts as a catalyst to increase the oxidation potential of the hydrogen peroxide. Ferrous sulfate is the most commonly used iron catalyst, which, when mixed with hydrogen peroxide, results in the generation of highly reactive hydroxl radicals. These radicals react with the VOCs to create water, carbon dioxide, oxygen, and dilute hydrochloric acid as by-products. With potassium permanganate, the potassium permanganate dissociates in an aqueous solution and the resulting permanganate ions oxidize compounds like TCE and PCE. Other by-products include carbon dioxide, chlorine, dilute hydrochloric acid, and some chloride and hypochlorite salts. The reactions are exothermic and temperature and pressure would increase as the reactions proceed.

Effectiveness

In situ oxidation is a relatively new and innovative application in groundwater remediation that appears to be effective for the removal of both dissolved VOCs and DNAPL from groundwater. As with AS/VE, the effectiveness of this process for the treatment of areas of possible residual (i.e., hot spot) or DNAPL accumulation would be limited by the ability to bring the oxidizer reagent into direct contact with the pool(s) of contaminated material or DNAPL. Due to the fractured nature of the weathered saprolite and bedrock materials beneath the Crossley Farm site and the depth of the contamination, this may be difficult to achieve. In addition, based on the monitoring data, the concentration of the possible TCE DNAPL may be very high, on order of 100,000+ ug/L, directly beneath the borrow pit. Such elevated concentrations would require high concentrations of the oxidizer reagent that could negatively impact the soil texture and stability. A pilot-scale treatibility test would be required to evaluate the site-specific effectiveness of this process.

Implementability

In situ oxidation may be implementable at the site, but due to the areal extent of the 100+ ug/L and 1,000+ ug/L TCE plumes would require the installation of numerous injection points. The potential DNAPL or hot spot area of the contamination plume may be more amenable to treatment, however the depth of the contamination and possible DNAPL pool(s) would make application somewhat difficult to implement. This technology would require the performance of a pilot-scale test to verify its site-specific effectiveness, assess the impact of the chemical oxidizer to the soil stability, and to determine the selection of the optimum oxidizing reagent.

Costs

Capital and O&M costs for in situ chemical oxidation utilizing either Fenton's Reagent or potassium permanganate would be high for the dissolved TCE plume, but are expected to be moderate for remediation of the residual or DNAPL plume.

Conclusion

In situ chemical oxidation is retained for development of remedial alternatives for limited areas of the groundwater plume (i.e., hot spot).

3.2.6 <u>Ex Situ Treatment</u>

Under this technology, extracted groundwater would be treated onsite prior to discharge back to the aquifer or to a nearby surface water location. In this section treatment technologies for the removal of the contaminants are identified and screened. Ideally, treatment would reduce contaminant concentrations to below PRGs or MCLs.

3.2.6.1 Air Stripping

Air stripping is an aeration process that utilizes counter-current air flow to promote the transfer of VOCs from the aqueous phase to the vapor phase. Carrier gas, such as air or steam, is purged through the contaminated water. Volatile compounds with greater affinity for the gas phase than the aqueous phase will partion to the air and subsequently be removed from the stripper by fans or blowers. Removal efficiencies of 50 percent to more than 99 percent can be achieved for VOCs, depending on operating conditions, column stripper sizing, packing material, and physical and chemical properties of the organic contaminants. Air stripping is typically most effective for the removal of VOCs with a Henry's Law constant greater than or equal to 3.0 atmosphere-liter per mole (atm-L/mole). However, significant concentrations of other organics can hinder the removal of VOCs, especially when low discharge concentrations are desired. Air stripping is not effective on less volatile organics or inorganics.

The counter-current packed tower or packed column is the most commonly used air-stripping configuration. Water is distributed over the top of the unit while air is forced upward through the bottom. Loosely fitted packing material serves to increase the air/water interface area to provide maximum mass transfer. Another increasingly common configuration is the low-profile air stripper, which consists of one or a series of aeration trays in place of a packed tower. The contaminated water is sprayed into the inlet chamber and flows along the baffled aeration trays. Air is blown up through hundreds of small holes in the trays, forming a froth of bubbles that provide a large mass transfer surface area where volatilization occurs. Key factors that influence air stripping process performance include air-to-water ratio, depth and type of packing material or tray configuration, operating temperature, surface hydraulic loading, and contact time.

Steam stripping is similar to air stripping, except that steam, rather than air, is used as a carrier gas and provides heat to enhance removal of contaminants. Steam stripping is generally considered for product recovery, for enhanced removal of VOCs from highly contaminated waste streams, and for the removal of less volatile organic compounds.

Packed tower aeration (PTA) is designated a best available technology (BAT) under the National Primary Drinking Water Regulations Implementation (40 CFR 142.62) for a number of VOCs, including some detected in site groundwater (TCE, PCE, carbon tetrachloride, cis-1,2-DCE, and 1,1,2-trichloroethane).

Effectiveness

Air stripping is a well-proven and reliable technology that would be effective for removing the VOCs from groundwater found at the site. Removal efficiencies greater than 99 percent can theoretically be achieved for the site contaminants of concern (TCE, PCE, 1,1-dichloroethene). Steam stripping and air stripping would be similarly effective for treating the contaminant concentrations anticipated for most of the treatment duration.

Since the stripping process only removes the contaminants from the water and concentrates them in the offgas, the offgas may have to be treated by other means (e.g., granular activated carbon adsorption, condensation, catalytic oxidation, or thermal destruction) to meet air emissions requirements. The need and type of offgas treatment depends on the specific contaminants and their concentrations. It is likely that offgas treatment would be required for the treatment of site groundwater.

Implementability

Air stripping and steam stripping would be readily implementable at the site. The equipment and resources necessary to implement air and stream stripping are readily available from commercial vendors. To meet Pennsylvania air quality standards, treatment of vapor emissions may be required. If steam stripping is implemented, a somewhat higher waste stream volume may be generated; however, condensation of organics and recycling of process water could minimize excess waste.

A maintenance problem associated with air stripping towers is the channeling of flow resulting from clogging in the packing material. Common causes of clogging include high oils, suspended solids, iron concentrations, and slightly soluble salts such as calcium carbonate. These problems can be mitigated with effective pre-treatment of the influent.

Air stripping systems are typically available for commercial and industrial applications.

Costs

The capital costs of implementing air stripping are low, and O&M costs range from low to moderate depending on influent contaminant concentrations, the degree of removal required, and the type of offgas treatment required. The capital costs of steam stripping are moderate and O&M costs are moderate to high, primarily because of increased energy costs.

Conclusion

Air stripping is an effective and reliable technology for removal of most site-related VOCs from contaminated groundwater and will be retained in combination with other process options for the development of remedial alternatives. Steam stripping may be somewhat more efficient than air stripping for treating very high concentrations of organics and may be applicable at some point in the treatment of onsite groundwater. However, because steam stripping is much more expensive to operate, would not provide more effective treatment, and would generate a higher volume waste stream than air stripping, it will be eliminated from further consideration.

3.2.6.2 Carbon Adsorption

Activated carbon adsorption is a frequently applied technology to remove organic compounds from contaminated water. Activated carbon will adsorb many organic compounds to some extent, but is most effective for the less polar and less soluble compounds. A removal efficiency exceeding 99 percent is possible depending on the type of organic contaminants present and system operating parameters, such as retention time and carbon replacement frequency. The fundamental principle behind activated carbon treatment involves the physical attraction of organic solute molecules to exchange sites on the internal pore surface areas of the specially treated (activated) carbon grains. As the contaminated water or vapor is filtered through the adsorbent, the organic molecules eventually occupy all the surface sites on the carbon grains. The exhausted or "spent" carbon must then be either regenerated or disposed according to federal and state regulations.

Typical GAC adsorption treatment systems include atmospheric or pressurized columns operating in series and/or parallel configuration. Liquid-phase GAC columns are typically designed with backwashing capability to minimize solids fouling which would increase GAC replacement frequency. Factors such as pH and temperature of the influent, empty bed contact time (EBCT), surface area/volume ratio of the activated carbon, and solubility of the organic compound will affect the carbon adsorption process. The carbon usage is related to the EBCT, contaminant concentrations, desired effluent concentrations, and desired filter life.

High organic content in the influent can result in high carbon usage. Pretreatment can significantly extend the carbon's useful life, thereby reducing the need for carbon replacement or regeneration. Activated carbon units have been used to "polish" or final treat the water that has undergone other treatment processes which have removed the bulk of contaminants.

GAC is designated a BAT under the National Primary Drinking Water Regulations Implementation (40 CFR 142.62) for a number of VOCs including some detected in site groundwater (TCE, PCE, carbon tetrachloride, cis-1,2-dichloroethene, and 1,1,2-trichloroethane).

Effectiveness

Carbon adsorption is a well-proven, reliable technology used to remove organics from aqueous waste streams. Carbon adsorption would be effective in removing many of the organic compounds present in the site groundwater. However, activated carbon has low sorptive capacities for vinyl chloride, which will not be effectively or efficiently removed. Vinyl chloride has not been detected in groundwater from the Crossley Farm site, but has been detected in a surface water sample, and may eventually be detected in groundwater because it is the end product of the degradation process of chlorinated solvent compounds, like TCE and PCE. One potential impact to human health is the potential for bacterial growth on the carbon beds and resultant excess bacterial counts in the treated effluent. This condition may be addressed through periodic replacement of the carbon-media.

Implementability

Carbon adsorption is readily implementable for the removal of compounds like TCE, PCE and cis-1,2-dichloroethene. There are a number of vendors that can size and provide carbon adsorption units and also provide equipment regeneration or disposal services. The implementability of carbon adsorption treatment of contaminated groundwater at the site may be limited due to the high concentrations that have been observed to date. The high contaminant loading will result in a high demand for carbon in order to achieve the 99.99 percent removal efficiency that will be required to meet the MCL for TCE. Thus, the operation and maintenance of the system will be high.

For liquid-phase GAC adsorption applications, pretreatment would be required to prevent premature carbon fouling if the groundwater to be treated has a suspended solids concentration greater than 50 mg/L, or oil and grease concentrations greater than 10 mg/L, or calcium or magnesium concentrations greater than 500 mg/L. Based on the available site monitoring data, it is not expected that these concentrations would be exceeded. Spent GAC containing the concentrated organic contaminants would have to be regenerated, incinerated, or disposed in a hazardous waste landfill. Thermal, steam, and solvent treatments are the most common types of GAC regeneration technologies, which are typically conducted off-site. Special handling of the generated backwash liquids must also be taken into account.

A number of vendors are available who can provide activated carbon units.

Costs

The capital cost for implementation of a GAC adsorption system would be low to medium based on the sizing and complexity of the required system. Operation and maintenance costs would range from low to high, depending on the carbon usage rate, which is a function of the influent contaminant concentration and flow rate.

Conclusion

Activated carbon adsorption is a readily implementable technology that has a proven record in the removal of compounds like those found at the site. Treatment of extracted contaminated groundwater with activated carbon is retained in combination with other process options for the development of remedial alternatives.

3.2.6.3 Sedimentation

Sedimentation is a process that removes the suspended solids from a liquid by producing quiescent hydraulic conditions. This allows gravity to settle out the unstable solids from suspension. This technology may be used in conjunction with precipitation. Sedimentation can either be used for clarification, which is geared towards the production of supernatant water as free of suspended solids as possible, or for thickening, which is geared toward the production of subnatent sludge, as concentrated as possible. Clarification is generally used as a pre-treatment step. Thickening is generally used as a treatment residual management step to minimize the volume of sludges.

Effectiveness

Sedimentation by itself would not be effective for removal of the organic compounds from the site groundwater. However, this technology would be effective for the removal of excessive concentrations of suspended solids that would otherwise undermine the efficiency of organic removal technologies such as air stripping and GAC adsorption. This is not expected to be a necessary pretreatment step for the Crossley Farm site contaminated groundwater, but may be necessary if groundwater conditions change.

Implementability

Sedimentation would be readily implementable. This technology is well-proven and widely used. The required equipment is commercially available from a wide variety of manufacturers.

Costs

Capital and O&M costs for implementation of sedimentation would be low.

Conclusion

Sedimentation is not retained at this time.

3.2.6.4 Filtration

Filtration is a process using a porous medium to remove suspended solid particles from a liquid or a gas. It is a widely used technology in water and wastewater treatment for removing suspended solids prior to primary treatment processes or for the final cleaning and polishing of treated effluent. It is effective in removing organic and inorganic contaminants (particularly metals) that are bound to suspended solids in groundwater, often reducing the need for further treatment of these contaminants.

Liquid filtration may be accomplished by numerous methods including screens, fiberous fabrics (paper or cloth), or beds of granular material. Flow through a filter can be encouraged by pressure on the inlet side or by drawing a vacuum on the filter outlet.

Most types of liquid filters, except those utilizing disposable filter elements (such as cartridge filters) require periodic cleaning to remove the suspended solids accumulated in the filter medium and restore filtration effiency. This cleaning is typically performed with a countercurrent of water, or backwash, which carries away the solids retained on the filter medium.

Effectiveness

Filtration is widely used to remove particulate metals and organic compounds that are bound to suspended solids from aqueous waste streams. Filtering systems can be staged to progressively remove smaller materials; many system variations have been designed to reduce clogging and provide easy maintenance. Conventional filtration is not effective in removing dissolved contaminants.

Filtration would not of itself be effective for the removal of the majority of COPCs from the site groundwater. However, this technology would effectively reduce excessive concentrations of solids particles suspended in the groundwater which might otherwise undermine the efficiency of downstream treatment technologies such as air stripping and activated carbon adsorption.

No adverse impacts to human health or the environment are likely to occur.

Implementability

Filtration is a readily implementable technology. This technology is proven and widely used. Filtration systems are commercially available from a wide variety of manufacturers and can be readily ordered to almost any specification. Filter media will occasionally have to be replaced or regenerated, potentially resulting in the generation of sludges requiring specialized disposal.

Costs

Capital costs for the implementation of filtration units are typically low, as are O&M costs. O&M costs may increase if high turbidity in the pumped groundwater requires additional filter maintenance.

Conclusion

Filtration is an effective and implementable technology to remove suspended solids from an aqueous waste stream. Filtration will be retained in combination with other process options for groundwater treatment for particulate metals removal, and as a safeguard for sensitive treatment processes such as activated carbon and air stripping.

3.2.6.5 Equalization

Equalization is a process that creates a surge capacity or "wide spot" at the head end of a treatment system to lessen fluctuations in incoming water flow and/or allow for the blending of multiple streams of different composition. Flow equalization only requires the use of an adequately sized tank. Stream blending equalization generally requires the use of some mechanical agitation device, such as a mixer.

Effectiveness

Equalization would not of itself be effective for the removal of any of the organic compounds from the groundwater impacted by the Crossley Farm Site. However, this technology would effectively enhance the overall performance of any treatment system by insuring that the flow and composition of the incoming groundwater is as constant as possible. Slugs of highly contaminated groundwater would be mitigated prior to entering the remainder of the treatment process. Based on previous characterization of the site groundwater and the possible pumping design, it is reasonably likely that such pretreatment would be required.

Implementability

Equalization is readily and easily implementable. This technology is proven and widely used. The required tanks and mixing equipment are commercially available from a number of manufacturers and come in a variety of sizes and materials.

Costs

Capital and O&M costs for equalization would be low.

Conclusion

Equalization is retained in combination with other process options for the development of remedial alternatives.

3.2.6.6 Chemical Oxidation

Oxidation is a process in which various components in a waste stream are chemically transformed to less toxic forms by the addition of a oxidizing agent. Chemical reagents typically used are chlorine, potassium *permanganate, ozone, or hydrogen peroxide. Oxidation is a well-established technology that is capable* of destroying a wide range of organic molecules and precipitating inorganic compounds out of solution. Oxidation often requires adjustment of the pH of the groundwater to be treated within a prescribed range, typically 8.0 to 9.0.

Effectiveness

Chemical oxidation is effective for the removal of both volatile and semivolatile organic compounds at concentrations typically less than found in the site groundwater. A number of pilot scale tests for remediation of TCE DNAPL using potassium permanganate have shown positive results.

Most oxiding agents are commercially available through a variety of vendors and have historically been used for water and wastewater treatment. All the oxidizing agents have varying degrees of effectiveness in degrading the contaminants of concern present in site groundwater. One benefit of using some of these oxidizing agents is that they also have a disinfecting effect and would kill or inactivate pathogens that are harmful to humans.

Some of the oxidizing agents may be used in combination to provide more complete degradation or destruction of organic contaminants. However, treatment residuals and intermediate by-products may be toxic and require additional treatment. The effectiveness of these oxidizing agents is dependent on the chemicals to be treated, the presence of naturally occurring organic chemicals that may compete with or interfere in oxidation, pH, temperature, dissolved minerals, and how amenable the chemicals are to oxidation.

Implementability

Chemical oxidation is an implementable, conventional water treatment process that is widely used and commercially available. Hydrogen peroxide is available through several vendors and would need to be transported to the site and would require storage facilities. Gases such as oxygen and chlorine would need to be delivered to and stored at the site for use. The storage of oxidizing chemicals requires that site operations take industrial safety procedures into consideration and that protocols for addressing accidental discharge and releases be developed. Permits may be required if gases are used that may result in emissions to the ambient air. Measures may be required to reduce those emissions to acceptable levels.

Costs

The capital and O&M costs for chemical oxidation vary from low to high, depending on the specific chemical selected, the equipment required, and associated safeguard mechanisms.

Conclusion

Oxidation is an effective and implementable treatment process for certain site-specific groundwater contaminants. Oxidation is retained in combination with other process options for groundwater.

3.2.6.7 Enhanced Oxidation (UV Oxidation)

Enhanced oxidation processes use a controlled combination of either ozone or hydrogen peroxide and ultraviolet (UV) light to induce photochemical oxidation of certain organic compounds. Ozone has been used extensively for purification, disinfection, and odor control of drinking water.

UV radiation is electromagnetic energy whose wavelengths fall between those of visible light and X-ray radiation on the electromagnetic spectrum. UV energy is capable of breaking down or rearranging a molecular structure, depending on the dissociation energies of the chemical bonds within the structure. The combination of ultraviolet radiation with ozone or hydrogen peroxide treatment results in the oxidation of organic contaminants at a rate many times faster than that obtained from applying UV light alone.

A typical continuous-flow hydrogen peroxide/ozone and UV system consists of an oxygen or air source, an ozone generator or hydrogen peroxide feed system, a UV/oxidation reactor, and an ozone decomposer. Flow patterns and configurations are designed to maximize exposure of the wastewater to the UV radiation, which is supplied by an arrangement of UV lamps. Typical reactor designs range from mechanically agitated reactors to spray, packed, and tray-type towers. If ozone is utilized, reactor gases are passed through a catalytic ozone decomposer, which converts remaining ozone to oxygen and destroys any volatiles.

Effectiveness

Enhanced oxidation with hydrogen peroxide/ozone and UV technology has been proven effective for the destruction of halogenated organic compounds, benzene derivatives, and various aliphatics hydrocarbons. Effectiveness varies greatly depending on the contaminant of concern. For the impacted groundwater at the Crossley Farm Site, the chlorinated alkenes such as TCE and PCE should be readily removed.

Implementability

Enhanced oxidation with hydrogen peroxide/ozone and UV would be readily implementable. However, only a few vendors currently offer this technology. Recent improvements have been made by vendors of this technology to minimize energy usage and reduce UV lamp fouling problems. With this treatment, no toxics are emitted to the atmosphere or adsorbed onto media that require further treatment or disposal. Hydrogen peroxide is a strong oxidizing agent; therefore, diking and other engineering controls are required to minimize potential risks associated with peroxide releases.

Costs

The capital cost for enhanced oxidation with hydrogen peroxide/ozone and UV would be moderate to high. Operation and maintenance costs vary significantly depending on flow rate, and contaminant type and concentration.

Conclusion

Enhanced oxidation with hydrogen peroxide/ozone and UV is eliminated from further consideration due to fact that air stripping is more cost effective and most likely poses fewer operational problems.

3.2.6.8 Coagulation/Flocculation

Coagulation/flocculation is a process which consists of adding certain chemical reagents to a water or wastewater stream that result in the agglomeration of small suspended solids particles into larger ones, thus increasing significantly the effectiveness of sedimentation. All coagulants are capable of removing some organic compounds, especially those with large molecular structures.

Effectiveness

Coagulation/flocculation would not of itself be effective for the removal of the site-related organic compounds from the groundwater impacted by the site. However, this technology would significantly enhance the effectiveness of suspended solids removal technologies, such as sedimentation and filtration. Based on previous characterization of the site groundwater, it may be likely that such technology would be required.

Implementability

Coagulation/flocculation would be readily implementable. This technology is proven and widely used. The required equipment and chemicals are commercially available from a wide variety of manufacturers and suppliers. Key process parameters include reagent dosages, pH adjustment requirements, temperature, influent groundwater characteristics, and sludge handling requirements. Jar tests and pilot tests are required to determine the most effective chemicals for site-specific contaminants and to assess chemical doses that are efficient and economical.

Costs

Capital and O&M costs for coagulation/flocculation would be low.

Conclusion

Coagulation/flocculation is retained in combination with other process options for the development of remedial alternatives.

3.2.6.9 Neutralization/pH Adjustment

Neutralization/pH adjustment is a process used to achieve the pH range necessary for optimum removal of contaminants or required for permitted discharge of treated groundwater. This is accomplished by the controlled addition of acidic or alkaline reagents to the groundwater to be treated.

Effectiveness

Neutralization/pH adjustment would not of itself be effective for the removal of the COPCs in the groundwater, but it would be required to insure the effectiveness of such technologies as oxidation or to allow surface discharge of the treated groundwater. Neutralization/pH adjustment would also enhance the effectiveness of such pretreatment technologies as coagulation/flocculation and sedimentation. A review of the site data indicates that the average pH range for site groundwater is approximately 5 to 8.

Implementability

Neutralization/pH adjustment is a readily implementable technology. The technology is widely used and has a proven record. The required equipment and chemicals are commercially available from a wide variety of manufacturers and suppliers.

Costs

Capital and operating costs for a neutralization/pH adjustment system are low.

Conclusion

Neutralization/pH adjustment is retained in combination with other process options for the development of remedial alternatives.

3.2.6.10 Reverse Osmosis

Reverse osmosis is a filtration technology that uses a semi-permeable barrier that will allow the passage of only certain components of a solution. The membrane is permeable to water but impermeable to most dissolved substances, both organic and inorganic. The driving force is an applied-pressure gradient to overcome the osmotic pressure of the contaminated solution. Relatively clean water is produced on the down-flow side of the membrane, the rejected organic and inorganic compounds remain on the up-flow side as a concentrated water stream (a "brine") that requires further treatment or disposal.

Reverse osmosis systems are operationally sensitive. Therefore, close monitoring of the temperature, pressure, and pH of the contaminated solution is necessary. In addition, the chemical and physical structure of the membrane must be closely monitored because the contaminants in the solution may react with and reduce its integrity.

Effectiveness

Reverse osmosis is effective in concentrating dilute solutions of many inorganic and some organic solutes. Reverse osmosis may reduce excess dissolved solids, reduce or remove many metals, and produce almost turbidity free water. The primary application of reverse osmosis is desalinating brackish water for potable use. However, reverse osmosis may not be appropriate for the primary treatment of groundwater at the site because the primary contaminants are chlorinated organics that may degrade the reverse osmosis unit membranes. The reject stream would consist of relatively concentrated organics that would require additional treatment or off-site disposal.

Implementability

Although equipment and resources are specialized, the reverse osmosis process is commercially available. Reverse osmosis membranes, in general, are subject to deterioration and may require periodic replacement. Membranes have life expectances of about 2 years. Membrane deterioration and replacement frequency may be accelerated by the high concentrations of chlorinated compounds in site groundwater. Pretreatment may be required to optimize pH.

Cost

Capital and O&M costs of reverse osmosis are high.

Conclusion

Reverses osmosis is eliminated from further consideration as the primary treatment for supply systems because of effectiveness concerns and the availability of other more effective and economical technologies for addressing VOCs (i.e., air stripping, carbon adsorption).

3.2.6.11 Ion Exchange

Ion exchange is a process in which ionic substances are removed from the aqueous phase through adsorption of contaminant ions onto a resin exchange medium. The toxic ions are exchanged with relatively harmless ions held by the resin material. The resins are insoluble solids containing fixed cations or anions capable of reversible exchange in solutions with which they are brought into contact. Ion exchange is typically used by a public water supply to remove hardness and nitrates. Sodium chloride is typically used in ion exchange units as the exchange medium because of its low cost, but its use may result in high sodium levels in the finished water. The ion exchange resins will eventually be exhausted and must be regenerated. The regeneration waste contains a high concentration of contaminants and must be further treated or disposed. The ion exchange process is relatively insensitive to flow rate.

Activated alumina (aluminum oxide) is an ion exchange medium that is typically used to remove excess fluoride from public water supplies. Although activated alumina can be used to remove lead ions from water supplies, less costly processes such as pH adjustment are employed by public water supplies to control lead levels (which typically results from leaching of lead solder of pipes).

Effectiveness

Ion exchange is effective for removing soluble metals and anions such as halides, sulfates, and nitrates. Because of resin capacity and regeneration restrictions, ion exchange is most applicable for treating dilute waste streams. Influent suspended solids must be very low to minimize fouling or plugging of the resin bed. Some organics, especially aromatics, can be irreversibly adsorbed by the resin, resulting in decreased capacity. Ion exchange may effectively remove dissolved metal ions from the groundwater or surface water. However, the presence of suspended solids and organics in the source water may cause fouling of the ion exchange resins thereby decreasing cation exchange capacity. Waters with high hardness will contain ions that would compete with other cations for sites on the exchange medium.

Sophisticated controls are required to detect breakthrough of contaminants when the capacity of the resin is close to being exceeded. The regenerate stream that is produced would require additional treatment prior to disposal.

Implementability

Ion exchange would be implementable. Many vendors are available to provide ion exchange units.

Cost

Capital and O&M costs for ion exchange point-of entry systems are relatively low.

Conclusion

Ion exchange (e.g., activated alumina) is not retained for further consideration.

3.2.7 Disposal

The technologies that can be considered under this General Response Action are onsite discharge via injection well, spray irrigation, or recharge trenches located within the groundwater recharge area, discharge to nearby surface water bodies, and the removal via tankers of contaminated water to an off-site permitted facility for treatment and discharge. The removal of water and disposal off-site may require the construction of a municipal or authority operated potable water supply (i.e., water main) for downgradient private well supplies. The reason for this is that the site sits at the top of Blackhead Hill that serves as a recharge zone for groundwater in the surrounding valley. The removal of large quantities of groundwater from the site could impact the quantity of groundwater available for withdrawal in the adjacent valley. Prior to on-site disposal, the groundwater would have to be treated onsite.

Effectiveness

On-site discharge would be an effective means of disposal for the site groundwater, provided that it would undergo adequate treatment to be environmentally acceptable. Off-site discharge of contaminated groundwater would be an effective option for treatment and disposal of site-related contaminants.

Implementability

On-site discharge, including discharge to a surface water body, should be an implementable technology. Injection wells and/or trenches could be constructed within the shallow and intermediate aquifer zones to allow for the discharge. Discharge to surface water would involve the construction of a pipe network for conveyance. Prior to discharge the groundwater would have to be treated to applicable PADEP standards and appropriate permits obtained. Due to the location of the site, the adjacent terrain, and the site geology, there may be some difficulty in implementing an on-site recharge system. Off-site recharge may be difficult due to property ownership issues.

Off-site discharge should also be an implementable technology however, may be difficult for certain alternatives due to the quantity of water to be handled. Contaminated water would be pumped via wells to a suitable holding tank which would be periodically emptied and the contaminated groundwater hauled via tank trailers to a RCRA permitted TSD facility for treatment and subsequent discharge. Permits for the extraction of the groundwater and transport would need to be obtained. All of these requirements are feasible and the necessary resources to satisfy them are available.

Costs

The capital and O&M costs for implementing on-site discharge would be low. The capital costs for off-site discharge would be low, however the O&M costs for transport and treatment/disposal are anticipated to be medium to high, depending on the pumping rate and long term volume to be removed.

Conclusion

On-site discharge, including discharge to a surface water body, is retained in combination with other process options for the development of remedial alternatives. Off-site discharge via transport and treatment at a TSD facility is not retained.

3.3 SELECTION OF REPRESENTATIVE PROCESS TECHNOLOGIES

The following technologies and process options are retained for development of remedial alternatives for *contaminated groundwater*:

- No Action
- Limited Action
  - Deed Restriction/Notices
  - Local Ordinances
  - Groundwater Monitoring
- Containment
  - Groundwater Extraction (Wells)
- Removal
  - Groundwater Extraction (Wells)
- In Situ Treatment
  - Air Sparging/Vapor Extraction
  - Chemical Oxidation
- Ex Situ Treatment
  - Air Stripping
  - Carbon Adsorption
  - Filtration
  - Equalization
  - Chemical Oxidation
  - Coagulation/Flocculation
  - Neutralization/pH Adjustment
- Disposal
  - Onsite Discharge

4

4.0 DEVELOPMENT AND DESCRIPTION OF REMEDIAL ACTION ALTERNATIVES

This section presents the proposed remedial alternatives for contaminated groundwater, impacted by the Crossley Farm Site. The remedial alternatives have been developed in accordance with the NCP of 40 CFR Part 300. Section 4.0 of this FS details the analysis of the alternatives per the criteria outlined in the NCP.

4.1 DEVELOPMENT AND DESCRIPTION OF REMEDIAL ALTERNATIVES – GROUNDWATER

The remedial alternatives for contaminated groundwater were developed in accordance with the NCP and EPA guidance. The NCP encourages development of alternatives that favor treatment technologies to address principal threats, and engineering controls to address relatively low, long-term threats. Additionally, the NCP suggests development of a range of treatment alternatives, including one or more engineering control alternatives, one or more innovative treatment alternatives, and the baseline No Action alternative. As noted in Section 3.0, however, several of the alternatives for groundwater will address only portions of the contaminated groundwater plumes (i.e., on-site portion; residual or hot-spot plume; plume >1,000 ug/l TCE; etc.) due to the current geographic extent of the plume, topography and/or geology of the site and surrounding area, and property ownership issues.

Based upon the technologies and process options retained in Section 3.0, the following alternatives have been developed for remediation of (1) the dissolved plume of groundwater that originates beneath the site (i.e., center of plume) and extends off-site into the valley and/or (2) the residual plume of groundwater that may be a possible DNAPL. Due to the hydraulic link between the groundwater beneath the site, and several on-site and off-site springs, the following alternatives may also impact the quality or flow rate of the source areas of the individual springs. The key components of Alternatives 1 through 9 are identified on Table 4-1.

Alternative 1	No Action
Alternative 2	Institutional Controls and Groundwater Monitoring
Alternative 3	Groundwater Containment of Center of Plume and On-Site Treatment/Recharge
Alternative 4	Groundwater Containment of Center of Plume, On-Site Treatment and Discharge to West Branch Perkiomen Creek
Alternative 5	In Situ Treatment of Residual Plume
Alternative 6	Residual/Hot Spot Plume Pumping and On-Site Treatment/Recharge
Alternative 7	Groundwater Containment of Valley Plume, On-Site Treatment and Discharge to West Branch Perkiomen Creek
Alternative 8	In-Situ Treatment of Valley Plume
Alternative 9	Groundwater Containment of Center of Plume, and Valley Plume, On-Site Treatment and Discharge to West Branch Perkiomen Creek

TABLE 4-1
GROUNDWATER REMEDIAL ALTERNATIVES COMPONENTS
FEASIBILITY STUDY
CROSSLEY FARM SITE
HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

	ALTERNATIVE	KEY COMPONENTS OF ALTERNATIVE
1	No Action	• Five-year reviews
2	Institutional Controls and Groundwater Monitoring	• Institutional Controls (deed notices/restrictions) • Long-term monitoring • Five-year reviews
3	Groundwater Containment of Center of Plume and On-Site Treatment/Recharge	• Design Investigation, Treatability Studies and Groundwater Modeling • Installation of groundwater well network for plume containment • On-site treatment of VOC-contaminated groundwater (i.e., by air stripping and activated carbon polishing) • Recharge of treated water • Institutional Controls (deed restrictions) • Long-term monitoring • Five-year reviews
4	Groundwater Containment of Center of Plume, On-Site Treatment and Discharge to West Branch of Perkiomen Creek	• Design Investigation, Treatability Studies and Groundwater Modeling • Installation of groundwater well network for plume containment • On-site treatment of VOC-contaminated groundwater (i.e., by air stripping and activated carbon polishing) • Discharge of treated water to West Branch Perkiomen Creek • Institutional controls (deed restrictions) • Long-term monitoring • Five-year reviews
5	In-Situ Treatment of the Residual Plume	• Design Investigation and Treatability Studies • In-situ treatment of residual groundwater plume (i.e., chemical oxidation) • Sampling and analysis of treatment monitoring wells and long-term monitoring • Institutional Controls (deed restrictions) • Five-year reviews
6	Residual/Hot Spot Plume Pumping and On-Site Treatment/Recharge	• Design Investigation and Treatability Studies • Installation of groundwater extraction wells • On-site treatment of VOC-contaminated groundwater (i.e., by air stripping and activated carbon polishing) • Recharge of treated groundwater on-site • Institutional controls (deed restrictions) • Long-term monitoring • Five-year reviews

TABLE 4-1
GROUNDWATER REMEDIAL ALTERNATIVES COMPONENTS
FEASIBILITY STUDY
CROSSLEY FARM SITE
HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

	ALTERNATIVE	KEY COMPONENTS OF ALTERNATIVE
7	Groundwater Containment of Valley Plume, On-Site Treatment and Discharge to West Branch of Perkiomen Creek	• Design Investigation and Treatability Studies • Installation of groundwater well network for plume containment • On-site treatment of VOC-contaminated groundwater (i.e., by air stripping and activated carbon polishing) • Discharge of treated water to West Branch Perkiomen Creek • Institutional controls (deed restrictions) • Long-term monitoring • Five-year reviews
8	In Situ Treatment of Valley Plume	• Design Investigation and Treatability Studies • In-Situ treatment of Valley Plume (i.e., chemical oxidation) • Sampling and analysis of treatment monitoring wells and long-term monitoring • Institutional controls (deed restrictions) • Five-year reviews
9	Groundwater Containment of Center of Plume and Valley Plume, On-Site Treatment and Discharge to West Branch of Perkiomen Creek	• Design Investigation, Treatability Studies and Groundwater Modeling • Installation of groundwater well network for plume containment • On-site treatment of VOC-contaminated groundwater (i.e., by air stripping and *activated carbon polishing*) • Discharge of treated water to West Branch Perkiomen Creek • Institutional Controls (deed restrictions) • Long-term monitoring • Five-year reviews

4.1.1 Alternative 1 – No Action

Under this alternative no measures would be taken to contain and/or treat the dissolved groundwater plume, the DNAPL source area or the resulting surface water at several on-site and off-site springs. No restrictions on the current and/or future withdrawal and use of groundwater beneath the site would be made.

Since contaminants would remain in groundwater beneath the site, a review of site conditions and risks would be conducted every 5 years as required by CERCLA. The reviews, to be conducted by EPA and/or PADEP would include sampling and analysis of various groundwater wells, an assessment of whether or not contamination migration has increased, and a determination if human or ecological receptors are at risk.

4.1.2 Alternative 2 – Institutional Controls and Groundwater Monitoring

This alternative has several components. The first component is that current and future use of groundwater at site would need to be monitored by a local agency or if not possible, restrictions on the withdrawal of groundwater would need to be placed in the site deeds. Long-term sampling and analysis of groundwater to determine the status of the residual zone and center of the plume, quality of groundwater beneath the site, and extent of the plume off-site would be the second component of this alternative. Sampling would be conducted on a bi-annual basis during the monitoring period unless conditions changed requiring either an increase or decrease in sampling frequency. The length of the monitoring period would be 30 years. As contaminants would remain in groundwater at the site, 5-year reviews would be conducted to review site conditions and to determine if the level of contamination poses an increased risk to human health and/or the environment.

The monitoring component would also include well maintenance. In case of change of site ownership during the course of the remedial activities, provisions would be incorporated into the property transfer documents to ensure that monitoring would continue.

4.1.3 Alternative 3 – Groundwater Containment of Center of Plume and On-Site Treatment/Recharge

The implementation of Alternative 3 will result in the containment of a portion of the 1,000+ ug/L dissolved TCE plume. The captured water will be treated ex-situ on-site, prior to being returned to the aquifer system. Alternative 3 would consist of the following major components: (1) pre-design investigation and treatability studies, (2) installation of a groundwater well system for hydraulic containment of the center of plume, (3) groundwater treatment, (4) groundwater well network for on-site recharge, (5) institutional controls, and (6) groundwater and surface water monitoring.

Component 1: *Pre-Design Investigation and Treatability Studies*

Pre-design investigations, including a pump-test(s) and sampling and analysis of groundwater, would be conducted to provide needed information regarding the underlying aquifer characteristics for the design of both the on-site extraction and re-injection systems. The pump test(s) would be used to define the hydraulic conductivity, transmissivity, and hydraulic gradient of the aquifer. The investigation would include at least one aquifer pump test, slug tests, groundwater elevation monitoring, and physical analysis of aquifer materials. Testing would be conducted in that area of the site where the extraction wells would be located and where re-injection of treated water would occur. Some additional wells may be required for conduct of these tests. Data obtained during the design investigation will also be used to conduct fate and transport analysis for determination of the length of treatment to achieve the RAOs.

To aid in the design of an effective groundwater treatment system, extracted groundwater, representative of that which will ultimately be pumped through the treatment system, would be collected during the pump test(s) and analyzed for design related parameters including the COPCs, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), pH, alkalinity, hardness, Total Organic Carbon (TOC), Chemical Oxygen Demand (COD), and certain inorganics (iron, manganese). The collected water will also be used for bench-scale treatability studies as a preliminary step to the final design.

As a significant amount of groundwater may be pumped on a daily basis to contain the center of the plume, groundwater flow modeling may be necessary to determine the effects of the pumping and subsequent re-charge on downgradient wells and properties. A determination of the need for flow modeling should be made following review of the pump test and aquifer characterization data collected during the pre-design phase. Data obtained during the pre-design investigation may also be used to conduct fate and transport analysis for determination of the length of treatment to achieve the RAOs and PRGs.

Component 2: Installation of Groundwater Well Network for Plume Containment

This component would consist of the installation of a well network for containment of the center of the plume. The well network would be designed and operated to hydraulically contain the on-site shallow and intermediate groundwater zones.

Figure 4-1 indicates the approximate outline of the TCE concentration isoplaths for shallow groundwater in the study area. Isoplath lines for 10 ug/L, and 1,000 ug/L are detailed. The lines represent the approximate boundary within which TCE concentrations are at or above the indicated concentration (i.e., 10, 100, or 1,000 ug/L.

Currently the approximate extent of the shallow dissolved TCE plume with concentrations at or below 100 ug/L is 68.4 acres (see Figure 4-1). Pumping and treatment of this portion of the plume would be very difficult due to the number of wells required, the amount of piping and pumping stations, the existing topography, and ownership issues related to the off-site contamination. Thus, containment of the 100+ ug/L plume will not be proposed for this alternative; instead, the withdrawal and containment of TCE and PCE contaminated groundwater will be concentrated in that area of the plume where concentrations exceed 1,000 ug/L. Figure 4-2 details the extent of the TCE plume in the intermediate groundwater zone.

Based on information obtained during the RI and assumptions regarding the hydraulic characteristics of the aquifer zones, the number of wells needed for containment of the on-site 1,000 ug/L plume were calculated on a preliminary basis (see Appendix A). To contain the western and southern perimeters of the plume a total of 41 wells placed at depths ranging from 100 feet to 400 feet would be installed. Figure 4-3 details the preliminary locations of wells for containment of the on-site 1,000 ppb plume. The estimated preliminary pumping rates ranged from 20 gpm to 150 gpm or about 320 gpm total. Equipment requirements would include submersible groundwater extraction pumps in each well and double-walled collection and transfer piping between wells to the on-site treatment plant.

Component 3: Groundwater Treatment

This component of Alternative 3 would be the treatment of the extracted contaminated groundwater at an on-site plant, using technology selected during the design phase. Based on the technology screening conducted in Section 3.0 of this FS, air stripping using packed columns and activated carbon are proven and appropriate technologies for removal of the site COPCs from groundwater. Air stripping can typically achieve TCE and PCE removal rates of 95 to 99 percent, which will be required in order to potentially achieve the groundwater preliminary remediation goal of 5 ug/L for the primary COCs. Additional removal can be achieved with an activated carbon polishing unit prior to discharge. Activated carbon adsorption can achieve removal rates for TCE and PCE of the same magnitude. Prior to treatment in either the air stripping columns or activated carbon units, the groundwater may be pumped through a filtration unit into an equalization tank in order to minimize flow and concentration upsets to the treatment system. During the remedial design, additional field and bench-scale work would be conducted in order to determine if equalization is required and the degree of filtration, pH adjustment, and metals removal that may be necessary. Limited data on TDS and TSS were gathered during the RI. Due to the variability of the

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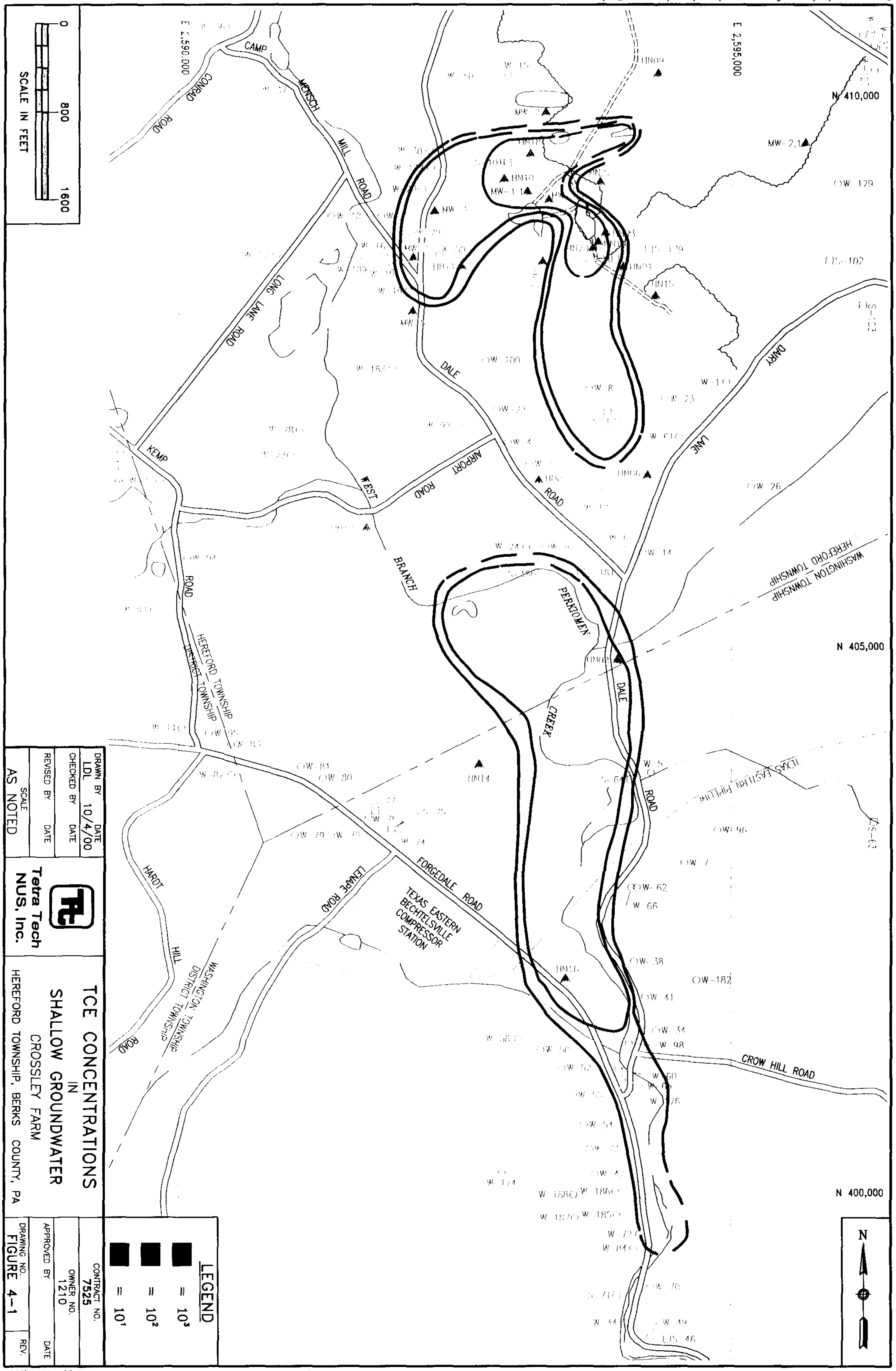

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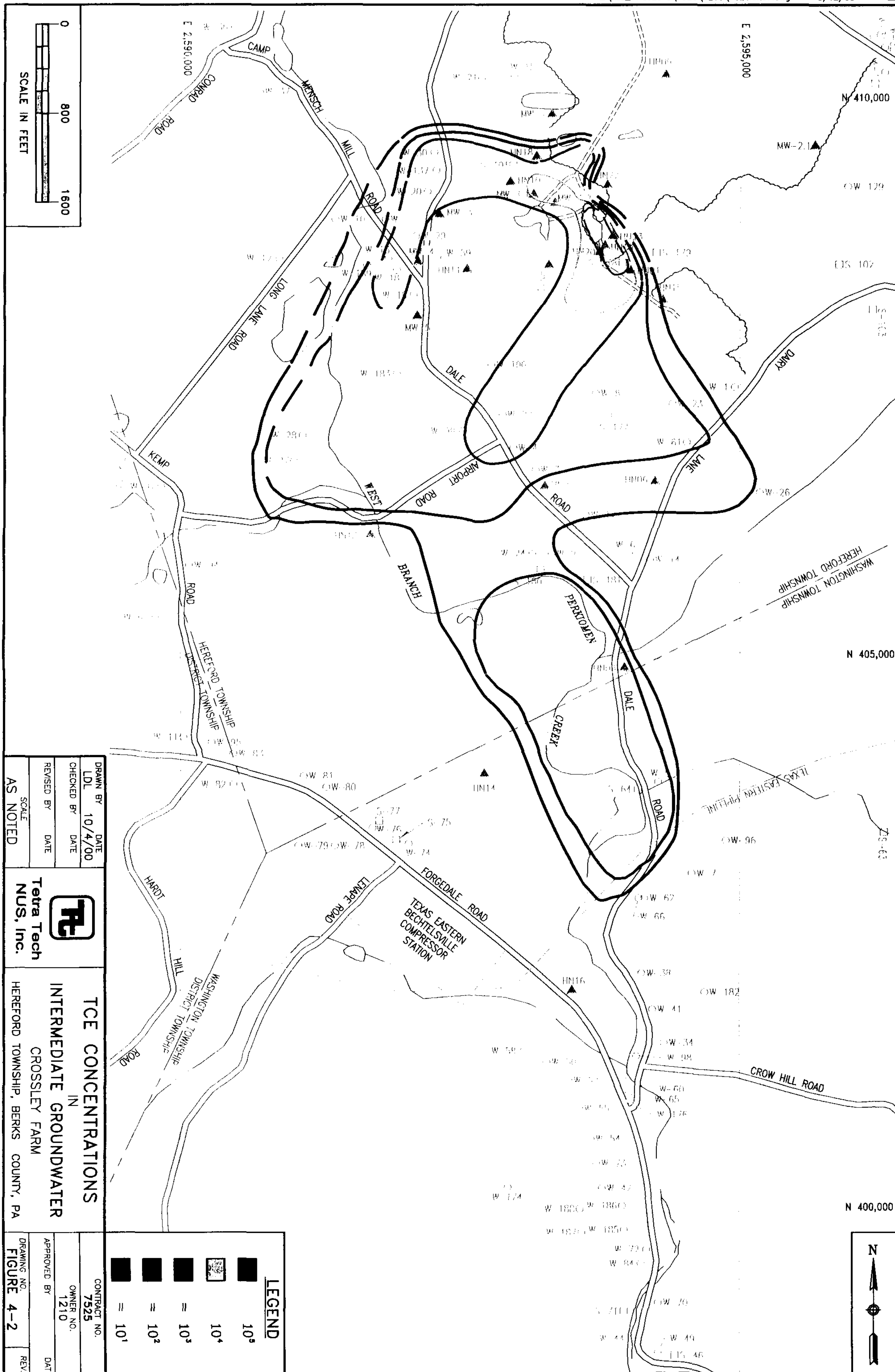
TCE CONCENTRATIONS
IN
INTERMEDIATE GROUNDWATER
CROSSLEY FARM
HEREFORD TOWNSHIP, BERKS COUNTY, PA
Tetra Tech NUS, Inc.
DRAWN BY LDL
DATE 10/4/00
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SCALE AS NOTED
CONTRACT NO. 7525
OWNER NO. 1210
APPROVED BY
DATE
DRAWING NO. FIGURE 4-2
REV.
LEGEND
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= 10⁴
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CAMP
CONRAD ROAD
MENSCH MILL ROAD
LONG LANE ROAD
KEMP ROAD
DALE ROAD
AIRPORT ROAD
WEST BRANCH
PERKIOMEN CREEK
DALE ROAD
DAIRY LANE
HEREFORD TOWNSHIP
WASHINGTON TOWNSHIP
HEREFORD TOWNSHIP DISTRICT TOWNSHIP
WASHINGTON DISTRICT TOWNSHIP
TEXAS EASTERN PIPELINE
FORGEDALE ROAD
LENAPE ROAD
HARDT HILL ROAD
TEXAS EASTERN BECHTELSVILLE COMPRESSOR STATION
CROW HILL ROAD
MW-2.1
HN18
HN06
HN11
HN14
HN16
MW-3
OW-129
OW-96
OW-26
OW-81
OW-80
OW-79
OW-78
OW-62
OW-66
OW-38
OW-182
OW-41
W-183
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W-92
W-74
S-75
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W-49

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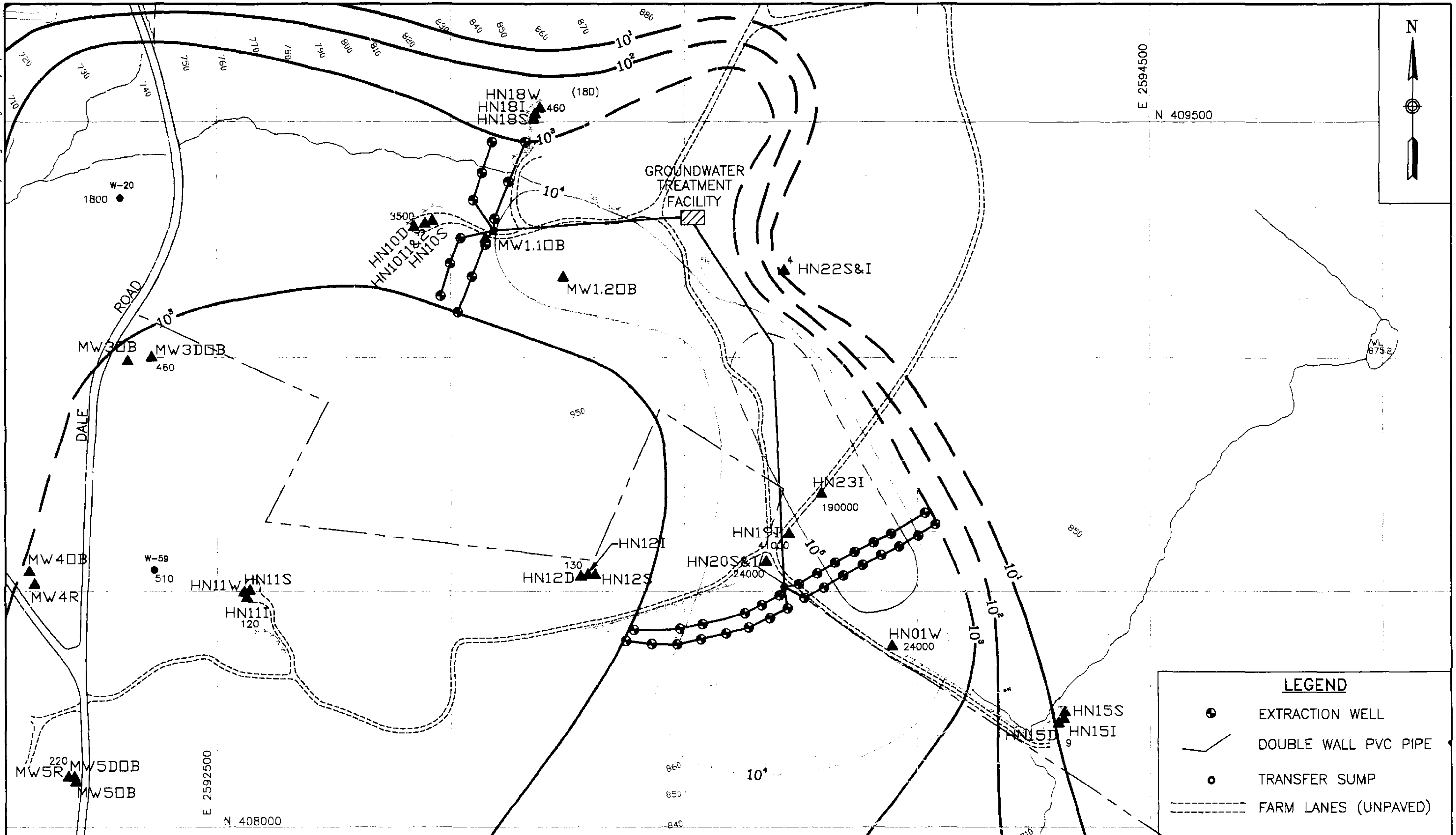

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NOTES:

1. ISOPLETHS ARE FOR TCE IN THE INTERMEDIATE AQUIFER.
2. THIS IS A PRELIMINARY CONCEPTUAL DESIGN. FINAL DESIGN TO BE DETERMINED DURING DESIGN INVESTIGATION.

DRAWN BY EEH/LDL	DATE 1/31/01	Tetra Tech NUS, Inc.	ALTERNATIVE 3 GROUNDWATER CONTAINMENT OF CENTER OF PLUME AND ON-SITE TREATMENT/RECHARGE CROSSLEY FARM HEREFORD TOWNSHIP, BERKS COUNTY, PA
CHECKED BY	DATE		CONTRACT NO. 7525
REVISED BY	DATE		OWNER NO. 1210
SCALE AS NOTED			APPROVED BY / DATE
			DRAWING NO. FIGURE 4-3 / REV.

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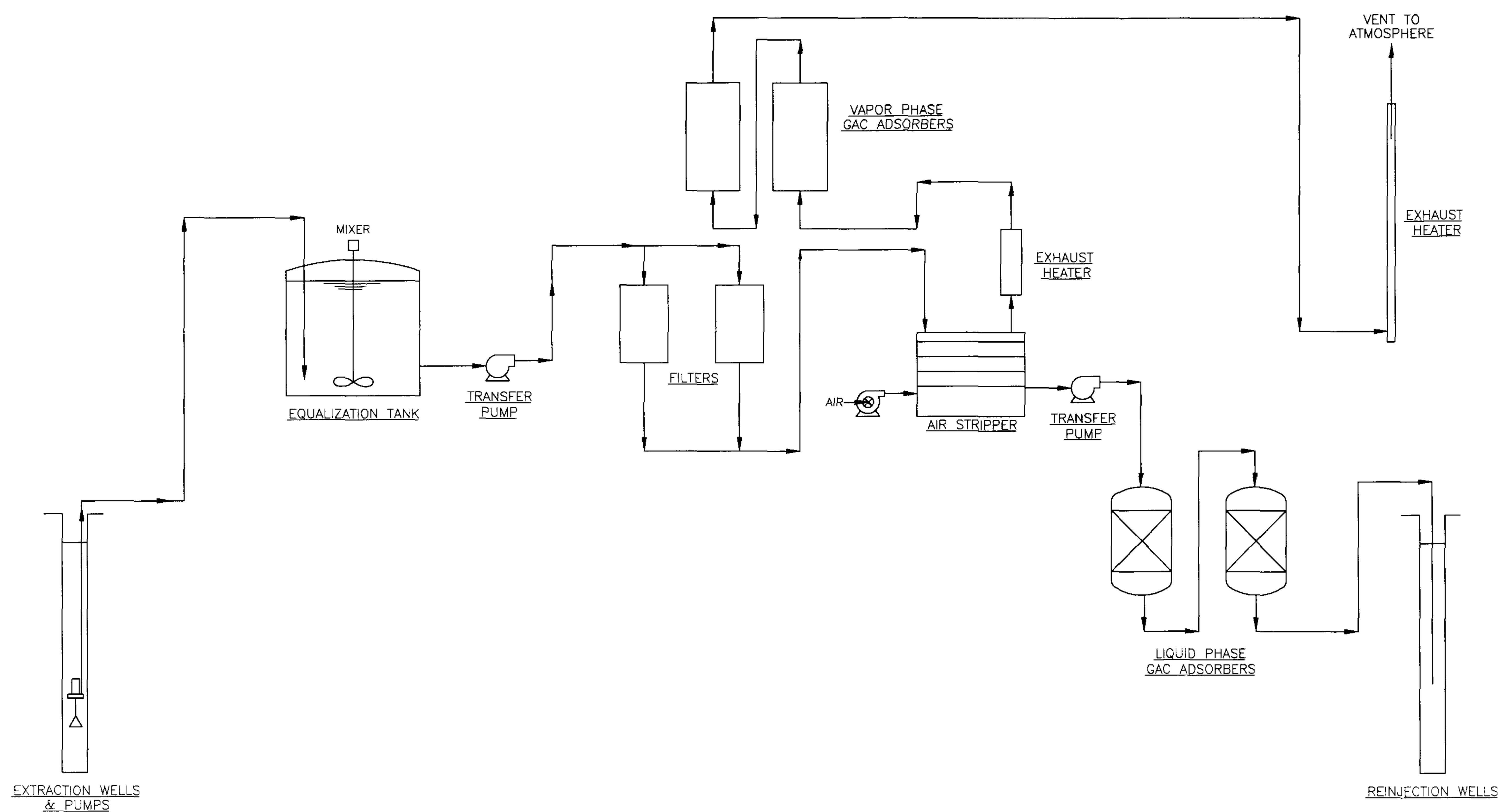
geology within the impacted area, it is recommended that additional samples be collected that will be specifically used for the process design. This work should be conducted on actual groundwater samples and flow proportions expected to be obtained during the pumping of the center of the plume. The final system design would be determined based on chemical and physical characterization data obtained during the pre-design investigation.

For purposes of this FS and based on the available site data, this component would consist of installing an on-site treatment system and operating this system for a period of 30 years. The groundwater treatment system would be housed in a 1,500 ft^2 pre-engineered and pre-fabricated building and consist of an equalization tank, a filter unit, an air stripper unit with off-gas treatment system, and a liquid-phase granular activated carbon (GAC) adsorption unit. A typical Process Flow Diagram (PFD) of the treatment system is shown on Figure 4-4. As shown on this diagram, the extracted groundwater would enter the system in the equalization tank; flow through that tank, the filter unit, the air stripper unit; the liquid-phase GAC adsorption unit and exit the system at the outlet of that unit. Prior to venting to the atmosphere, the exhaust from the air stripper unit would pass through an off-gas treatment system featuring vapor-phase GAC adsorption. Process design calculations for the conceptual treatment system are provided in Appendix B.

The purpose of the equalization tank would be to blend the groundwater from the various extraction wells to equalize the quality of the influent to the air stripper unit. The equalization tank could also be used to provide additional treatment, as may be required, such as pH adjustment. Based on a preliminary design for this FS, the equalization tank would be equipped with a mixer and sized at 12,000 gallons to provide approximately 30 minutes detention time under design flow conditions.

The equalized groundwater flow would be pumped by a 400 gpm centrifugal pump through the filter unit to the air stripper unit. The purpose of the filter unit would be to remove most of the suspended solids (including iron and manganese) which may be present in the groundwater and which, if not removed, could result in premature fouling of the air stripper unit. The filter unit would be of the pressurized type and equipped with multiple disposable filter elements installed in parallel to allow for continued service during the periodic replacement of a clogged element. Clogged filter elements would be disposed off site and replaced with fresh ones.

The equalized and filtered groundwater would then percolate down through the packing of a column type air stripper unit where it would be submitted to a countercurrent of air. The packing elements would fraction the groundwater flow into a multiplicity of very thin-film streams and this fractionating combined with the volatilizing effect of the air current would strip essentially all of the chlorinated VOCs from the groundwater. The air stripped groundwater would be collected in a sump at the bottom of the air stripper column and the offgas would exhaust the top of the column through a demister. The air stripper unit



NOTE: FINAL DESIGN TO BE BASED ON DESIGN INVESTIGATION/TREATABILITY STUDY.

DRAWN BY EEH/LDL	DATE 10/3/00	Tetra Tech NUS, Inc.	PROCESS FLOW DIAGRAM TYPICAL GROUNDWATER TREATMENT SYSTEM ALTERNATIVE 3 – FEASIBILITY STUDY CROSSLEY FARM SITE HEREFORD TOWNSHIP, BERKS COUNTY, PA
CHECKED BY	DATE		CONTRACT NO. 7525
REVISED BY	DATE		OWNER NO. 1210
SCALE NONE			APPROVED BY / DATE
			DRAWING NO. FIGURE 4–4 / REV.

Figure 4-4 would feature a 6 foot diameter column with 30 feet of loose packing and be equipped with a 3,800 cubic feet per minute (cfm) centrifugal blower to provide the necessary countercurrent of air.

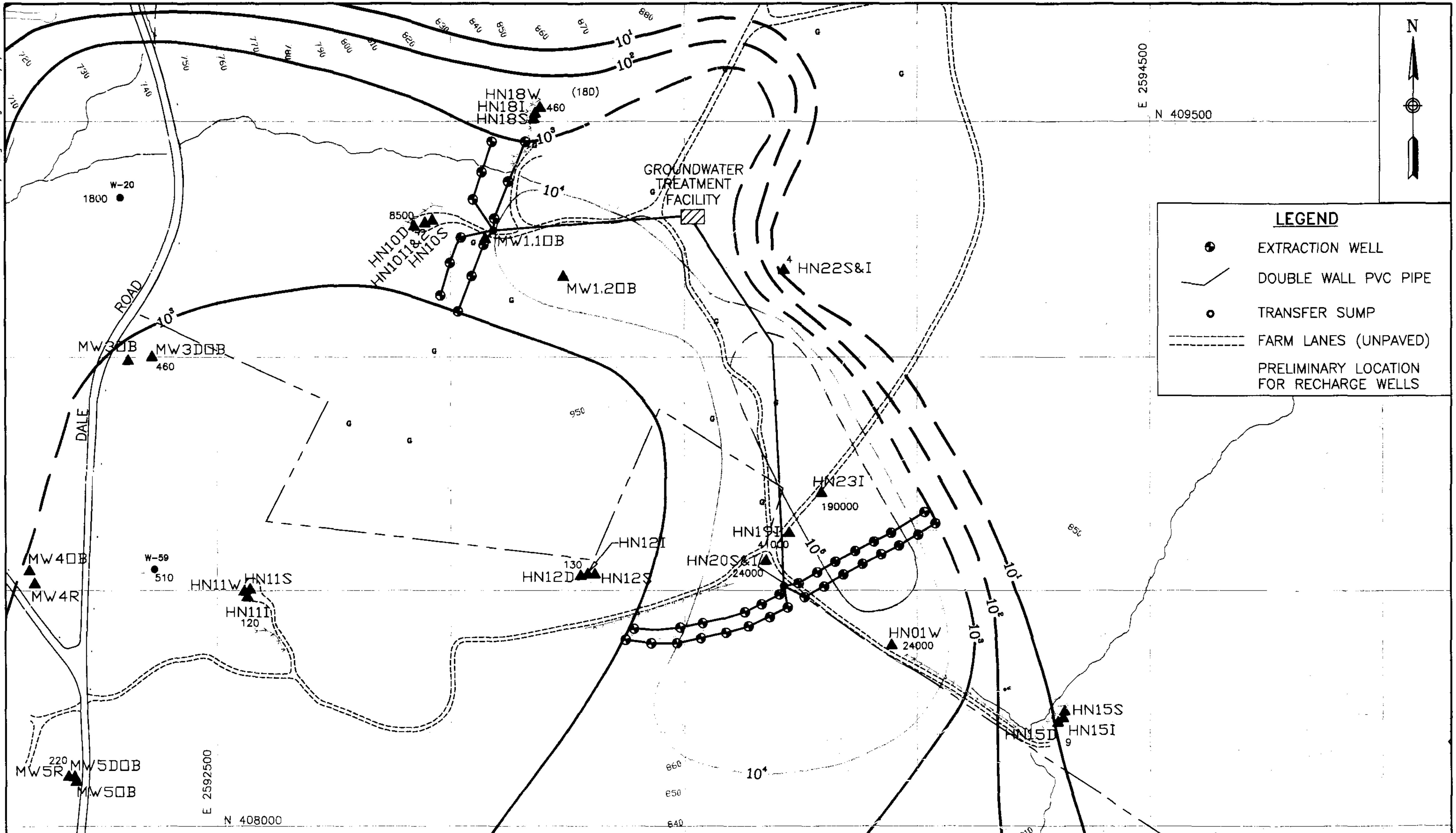
Prior to exhausting to the atmosphere, the offgas existing from the top of the air stripper column would pass through an offgas treatment system to remove volatilized contaminants. The offgas treatment system would consist of an electric 40 kilometer (kW) exhaust gas dryer followed by two vapor-phase GAC adsorption canisters, each holding 13,600 pounds of GAC and operating in series. The purpose of the exhaust gas dryer would be to reduce the relative humidity of the air stripper unit off gas from near 100 percent to approximately 50 percent to allow efficient operation of the vapor-phase GAC adsorption canisters. The majority of chlorinated VOCs in the extracted vapors would be removed by the lead GAC adsorption canister, with a lag canister provided for polishing purposes. Upon exhaustion of the GAC of the lead canister, it would be taken out for disposal or regeneration. The lag GAC adsorption canister would then be placed in the lead position and a fresh canister would be placed in the lag position. Based on available monitoring data, it is estimated that the lead GAC adsorption canister would be replaced at least quarterly during the 30 years of operation of the treatment system.

The groundwater collected at the bottom of the air stripper unit would be conveyed by a 400 gpm centrifugal pump to the liquid-phase GAC adsorption unit. This unit would consist of two canisters, each holding 20,000 pounds of GAC and operating in series. The low residual concentrations of chlorinated VOCs in the air stripped groundwater (approximately 3 to 4 ug/L) would be completely removed by the lead GAC adsorption canister and the lag canister would only be provided for contingency purposes. No replacement of either the lead or lag liquid-phase GAC adsorption canisters is anticipated to be necessary during the 30 years of operation of the treatment system. Both of the adsorption units would feature backwash capabilities to deal with potential long-term accumulation of suspended solids in the GAC beds.

Performance of the treatment system would be monitored. Performance monitoring would consist of collecting monthly water samples from the inlet and outlet of the treatment system and analyzing these samples for chlorinated VOCs, iron, manganese, and TSS. Performance monitoring would also consist of collecting quarterly gas samples from the outlet of the lead GAC adsorption unit of the air stripper offgas treatment system and analyzing these samples for chlorinated VOCs.

Component 4: Treated Water Recharge System

This component would consist of the discharge of the treated water to on-site and off-site groundwater by discharge into wells screened in the shallow and intermediate water-bearing zones. The preliminary location for placement of the groundwater recharge system is shown on Figure 4-5. The type of recharge



NOTES:

1. ISOPLETHS ARE FOR TCE IN THE INTERMEDIATE AQUIFER.
2. THIS IS A PRELIMINARY CONCEPTUAL DESIGN. FINAL DESIGN TO BE DETERMINED DURING DESIGN INVESTIGATION.

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DRAWN BY LDL	DATE 10/4/00	Tetra Tech NUS, Inc.	ALTERNATIVE 3 PROPOSED RECHARGE SYSTEM LOCATION	CONTRACT NO. 7525	
CHECKED BY	DATE			OWNER NO. 1210	
REVISED BY	DATE		CROSSLEY FARM HEREFORD TOWNSHIP, BERKS COUNTY, PA	APPROVED BY	DATE
SCALE AS NOTED				DRAWING NO. FIGURE 4-5	REV.

system, if constructable, will be determined during the pre-design investigation. The site topography and geology may prevent the installation of a typical well recharge system. For purposes of this FS it has been assumed that a well recharge system would be implementable. Treated groundwater would flow by polyvinyl chloride (PVC) single- wall piping to each well. Based on preliminary calculations approximately 40 wells may be required for re-injection. This component would also include regular monitoring and reporting of the flow rate and quality of the discharge water.

Component 5: Institutional Controls

Institutional controls would consist of deed notices or restrictions regarding the current and future use of groundwater on site. The institutional controls would be in place until such time on-site groundwater levels are at or below the PRGs.

Component 6: Groundwater Monitoring

The monitoring component would consist of the periodic collection and analysis of samples from on-site and selected off-site well locations. Groundwater samples would be collected from within the center of the contaminant plume to assess progress of the remedial efforts, downgradient of the leading edge of the plume to evaluate contaminant migration, and from a number of the impacted private water supplies to assess groundwater quality at impacted residences and businesses. Surface water samples would be collected from the on-site and off-site springs that have previously exhibited elevated site-related contaminant levels (i.e., nos. 10 and 11). The objective of the surface water sampling would be to monitor the effects of the containment pumping on the flow rates and quality of the individual spring source.

Monitoring would be performed over a period of 30 years and would consist of collecting samples from 20 locations. The samples will be analyzed for VOCs and select inorganics. The sampling would be conducted on a semi-annual basis unless conditions changed requiring either an increase or decrease in sampling frequency.

Data and statistical analysis reviews will be performed every fifth year, for a period of 30 years, to evaluate site status, assess the continued adequacy of the remedial activities, and to determine whether further action is necessary.

The monitoring component would also include well maintenance. In case of a change of site ownership during the course of the remedial activities, EPA and/or PADEP would meet with the new property owners to attempt to ensure that monitoring would continue.

4.1.4 Alternative 4 – Groundwater Containment of Center of Plume, On-Site Treatment and Discharge to West Branch Perkiomen Creek

Alternative 4 consists of several components and will result in the hydraulic containment of a portion of the on-site 1,000+ ug/L dissolved TCE plume, ex-situ treatment conducted on-site and off-site discharge of the treated water. Alternative 4 is the same as Alternative 3 except that the treated groundwater is discharged off-site into West Branch Perkiomen Creek. The major components are: (1) pre-design investigation and treatability studies including flow modeling, (2) groundwater well system for plume containment, (3) groundwater treatment, (4) treated water discharge to West Branch Perkiomen Creek, (5) institutional controls, and (6) groundwater and surface water monitoring.

Alternative 4 can only be implemented if additional work is conducted to determine the effect on downgradient residential wells, of the withdrawal, and ultimate removal, of approximately 320 gpm from the aquifer. The treated water will not be returned to the site aquifer as under Alternative 3, thus potentially decreasing the normal water table level. The additional work needs to include in-field pump tests and flow modeling that shows no negative impact to downgradient water users as a result of the off-site discharge. The additional work may not be required if a public water supply via water main is provided to nearby residences. A determination would need to be made during the pre-design phase.

Data obtained during the pre-design investigation may also be used to conduct fate and transport analysis for determination of the length of treatment to achieve the RAOs and PRGs. A determination of the need for this task will also be made during the pre-design phase.

Component 1: Pre-Design Investigation, Treatability Studies, and Flow Modeling

This component is the same as Component 1 of Alternative 3 with the addition of groundwater flow modeling to determine the downgradient effects from removal of 320 gpm from the site aquifer and measurement of stream flow in that area of the West Branch Perkiomen Creek where discharge might occur.

Component 2: Groundwater Well Network for Plume Containment

This component will be the same as for Alternative 3.

Component 3: Groundwater Treatment

This component of Alternative 4 would be the same as Component 3 of Alternative 3 with technology selection to occur during the pre-design phase following the collection of specific field data. Figure 4-6 is a schematic of the proposed treatment system.

Component 4: Treated Water Discharge to West Branch Perkiomen Creek

This component is the monitored discharge of about 320 gpm of treated water to the West Branch Perkiomen Creek. Treated water upon exiting from the on-site treatment system would flow through a buried single-wall pipeline from the site to a nearby location on the creek, west of Dale Road (see Figure 4-7). The exact location would be determined during the RA design and would be based on proximity to treatment system, site access, stream configuration, stream impact, and cost to implement. The pre-design investigation would also include an impact analysis on the addition of approximately 320 gpm of treated water to the West Branch. The treated water will be sampled on a monthly basis as it exits the treatment system prior to discharge. This sampling is included under Component 3 and is as described for Component 3 of Alternative 3. For purposes of this FS, approximately 2,000 feet of treated water discharge piping are estimated to be required.

Component 5: Institutional Controls

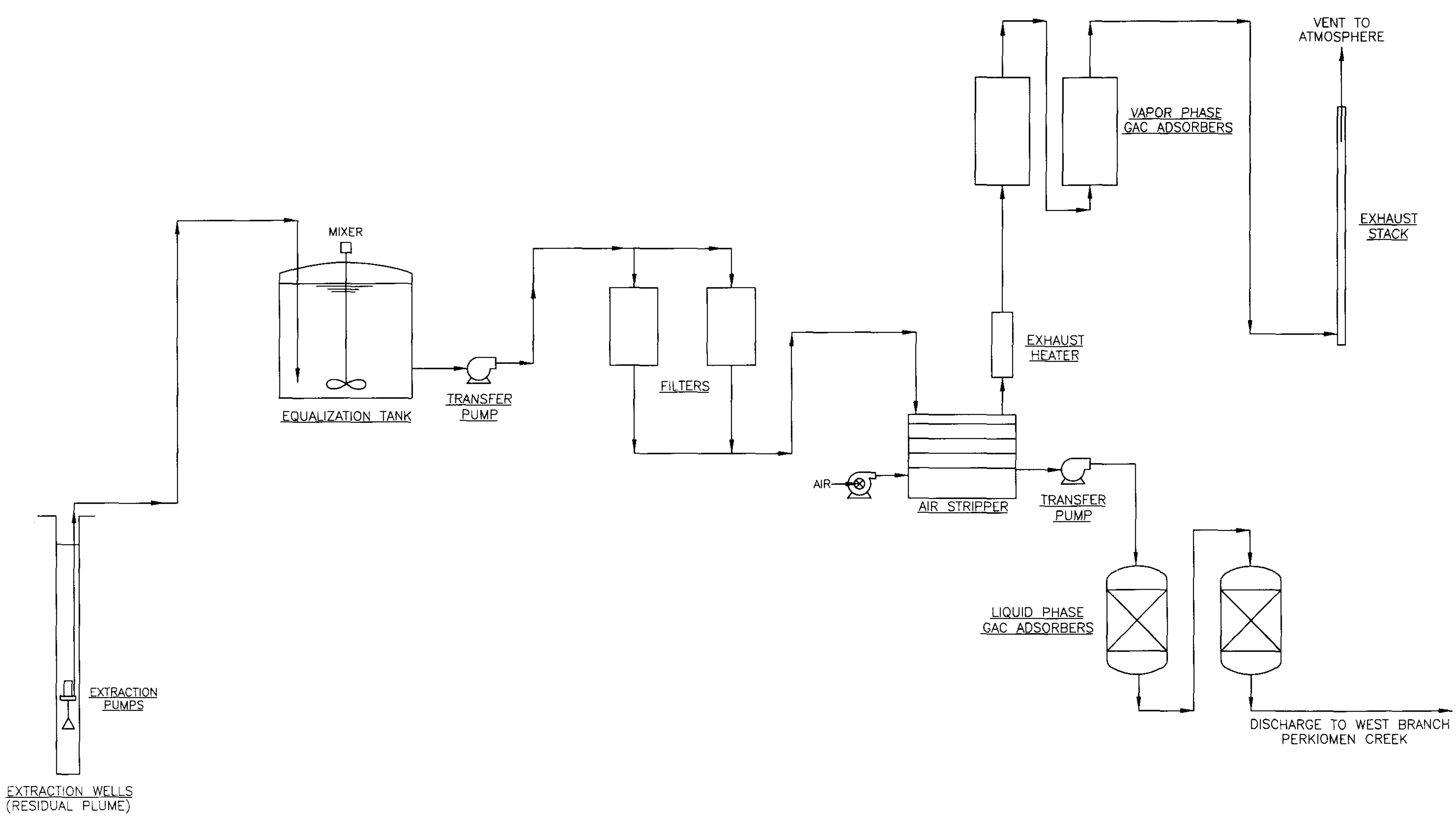
This component is the same as for Alternative 3.

Component 6: Groundwater and Surface Water Monitoring

This component is the same as for Alternative 3.

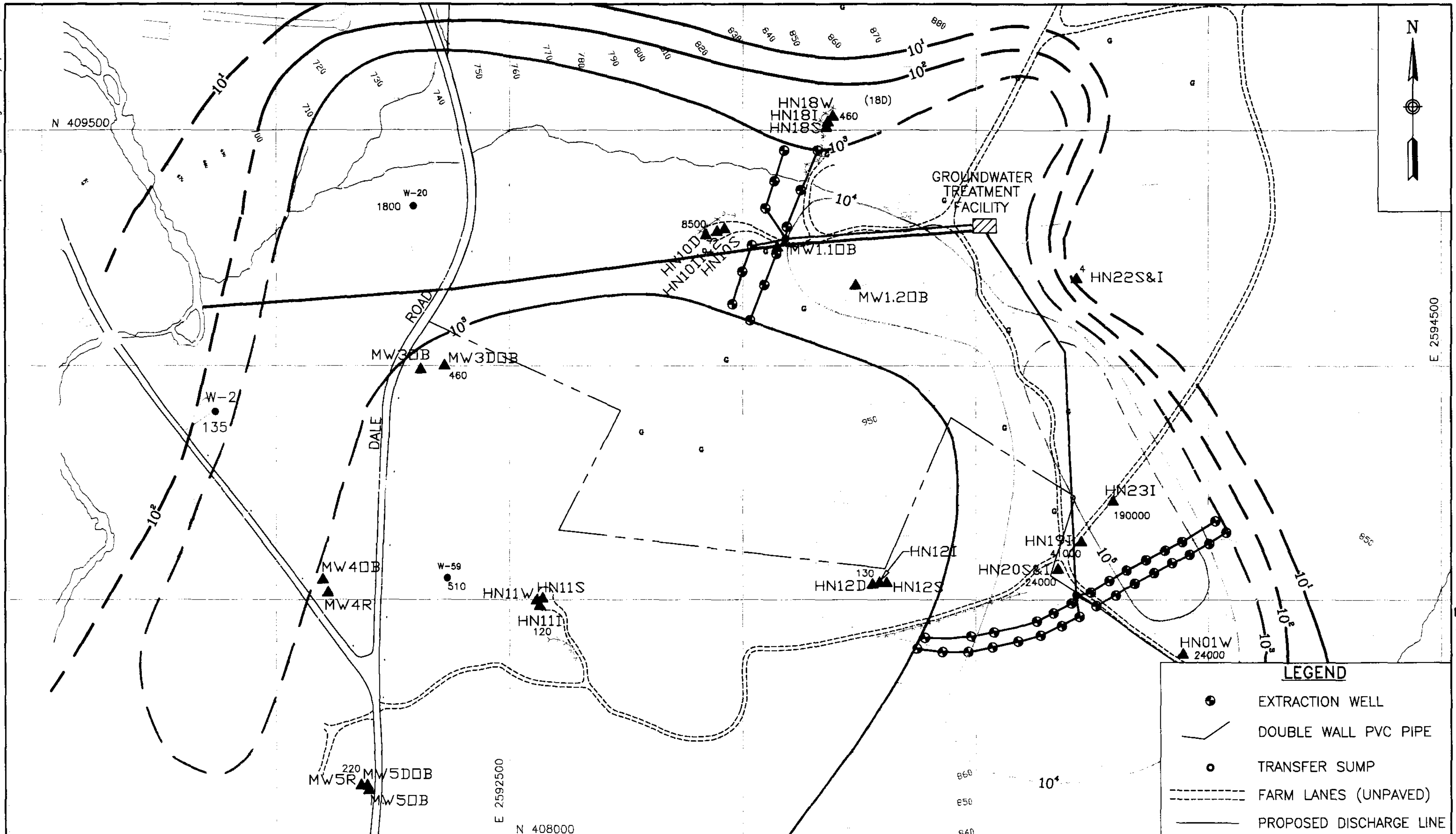
4.1.5 Alternative 5 – In-Situ Treatment of the Residual/Hot-Spot Plume

Under this alternative groundwater beneath and immediately downgradient of the former borrow pit will be treated in-situ using a site and contaminant-specific process selected during the pre-design phase. Based on historical information concerning the site activities, the former borrow pit area may have been used for the temporary staging of drummed waste materials. Groundwater samples collected in 1998 from wells HN-19, HN-20 and HN-23 exhibited TCE concentrations in the range of 24,000 ug/L to 190,000ug/L. In addition, samples collected from this area show an increase in TCE concentration as the depth of the groundwater sample increases. As noted in the RI, no visual evidence of a DNAPL has been found, however, the data strongly suggest the presence of DNAPL. As part of the remedial design,



NOTE: FINAL DESIGN TO BE BASED ON DESIGN INVESTIGATION/TREATABILITY STUDY.

DRAWN BY EEH/LDL DATE 10/3/00	Tetra Tech NUS, Inc.	PROCESS FLOW DIAGRAM	CONTRACT NO. 7525
CHECKED BY DATE		TYPICAL GROUNDWATER TREATMENT SYSTEM	OWNER NO. 1210
REVISED BY DATE		ALTERNATIVE 4 – FEASIBILITY STUDY	APPROVED BY DATE
SCALE NONE		CROSSLEY FARM SITE HEREFORD TOWNSHIP, BERKS COUNTY, PA	DRAWING NO. FIGURE 4–6 REV.



NOTES:

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2. THIS IS A PRELIMINARY CONCEPTUAL DESIGN. FINAL DESIGN TO BE DETERMINED DURING DESIGN INVESTIGATION.

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DRAWN BY LDL	DATE 10/4/00		ALTERNATIVE 4 PROPOSED TREATED WATER DISCHARGE LINE LOCATION CROSSLEY FARM HEREFORD TOWNSHIP, BERKS COUNTY, PA	CONTRACT NO. 7525	
CHECKED BY	DATE	Tetra Tech NUS, Inc.		OWNER NO. 1210	
REVISED BY	DATE			APPROVED BY	DATE
SCALE AS NOTED				DRAWING NO. FIGURE 4-7	REV.

exploratory wells are proposed to be constructed through the borrow pit area to delineate the vertical extent of TCE contamination and to visually determine if a DNAPL exists.

This remedial alternative would consist of the following components: (1) pre-design investigation and treatability studies, (2) in-situ treatment of contaminated groundwater within the residual plume using Fenton's Chemistry process technology, the Air Sparing/Vapor Extraction technology, or another appropriate technology, (3) sampling and analysis of treatment and long-term monitoring wells, and (4) institutional controls.

Component 1: Pre-Design Investigation and Treatability Studies

The technology evaluation presented in Section 3 identified several technologies possibly suitable for in-situ treatment of VOC contaminated groundwater. These include chemical oxidation and air sparging and vapor extraction (AS/VE). These are relatively new groundwater treatment technologies that have proven effective in limited field studies. The limited demonstration data for these technologies and the highly site and waste specific nature of in-situ remediation make it impossible to determine the likely effectiveness of either chemical oxidation or air sparing/vapor extraction without a site-specific treatability study. Therefore, a treatability study consisting of either bench-scale or pilot testing, or both, would be necessary to evaluate the effectiveness of these technologies and selection of the most appropriate one.

In addition to the site-specific treatability study, a pre-design investigation, consisting of a hydrogeologic evaluation and sampling and analysis of groundwater and aquifer materials within the boundary of the residual (Hot Spot) plume, would be required to support the design of the in-situ treatment system. The hydrogeologic investigation would be used to better define steady-state aquifer characteristics (i.e., hydraulic conductivity, gradient, and transmissivity) in order to determine the sizing, placement, and design of the treatment system. The investigation would be tailored to the specific data requirements of the selected in-situ technology, and may include slug tests, pump tests, groundwater elevation monitoring, and physical analysis of aquifer materials.

Sampling and chemical analysis of groundwater and aquifer materials would be conducted to determine the extent of the residual plume and/or DNAPL, and to better define the chemical composition of the groundwater and aquifer materials. The data would be used to aid in the selection and design of an effective in-situ treatment system and to determine the length of treatment required to achieve the PRGs.

Component 2: In-Situ Treatment of Residual/Hot-Spot Groundwater Plume

Following selection of an appropriate in-situ treatment technology, Component 2 would consist of the installation of the necessary treatment wells and equipment in order to carry out the process and subsequent treatment to achieve the PRGs. These may include injector wells for chemical or air addition to the aquifer and extraction or vacuum wells for removal of contaminants in liquid or vapor phase form. In addition, wells for the monitoring of the treatment process would also be installed in and around the treatment zone. The number of injector and monitoring wells will be defined during the RA design following the in-field pilot testing. The number of treatment process wells is dependent on the size of the source area (i.e., residual zone) which has not been completely defined. Figure 4-8 outlines the preliminary proposed area for in-situ treatment; the exact area will be defined during the remedial design.

For purposes of this FS it is assumed that in-situ treatment using chemical oxidation will be the selected process (see Appendix B). Between 100 to 150 injector wells are preliminarily estimated to be installed. Well diameter is estimated to be 2-inch. The groundwater within the residual plume will be treated in-situ with a solution of potable water amended with oxidizers, catalysts, and surfactants to effect a chemical reaction known as Fenton's Chemistry. The reaction results in the oxidation of complex organic contaminants, including TCE and PCE, to non-hazardous, naturally occurring acids that are further reduced to carbon dioxide, oxygen and water. Currently several vendors have patented injection equipment or treatment agents. Selection of the appropriated technology and vendor will be based on the in-field testing conducted during the RD.

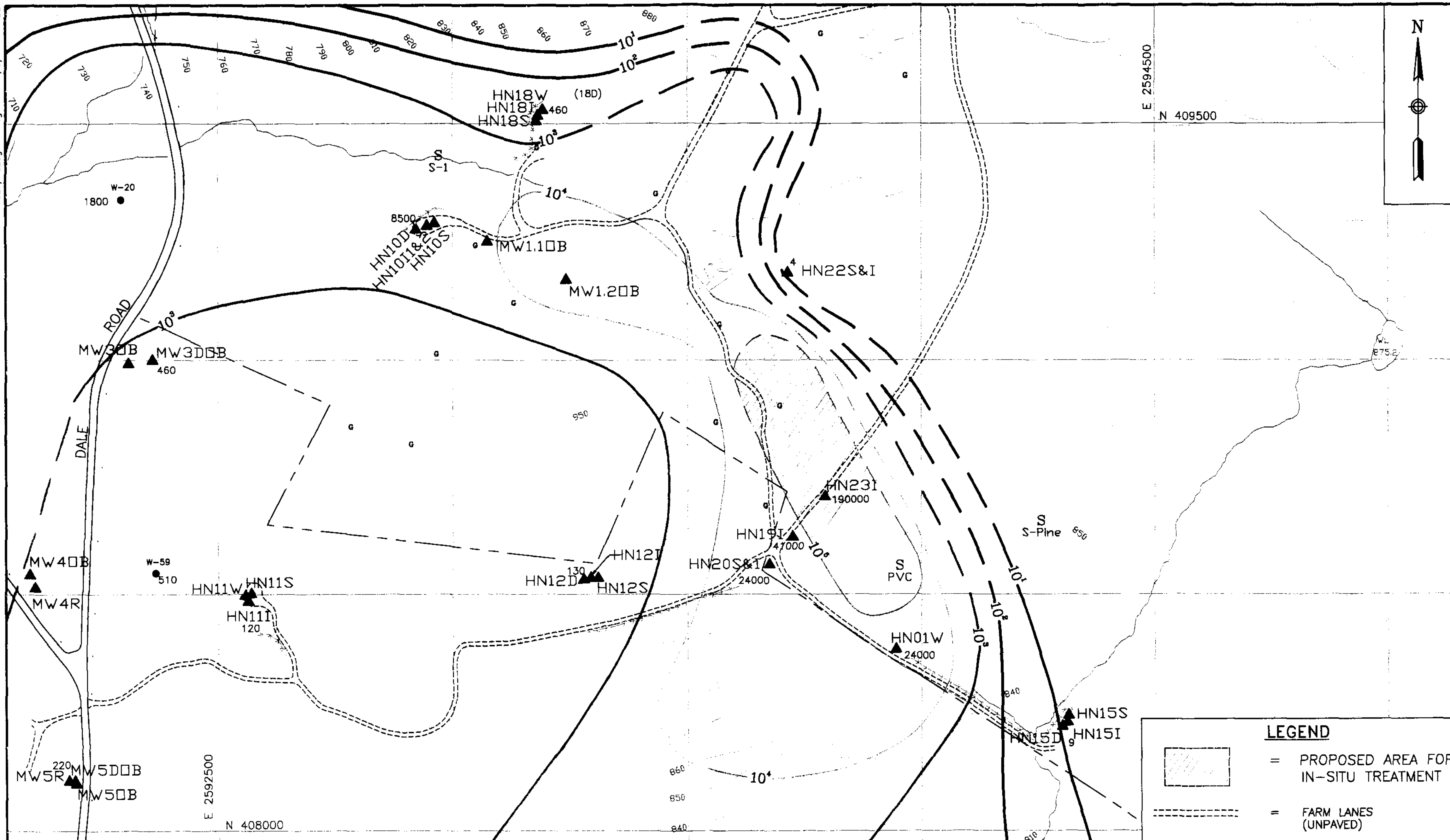
Component 3: Sampling and Analysis of Treatment Monitoring Wells and Long Term Monitoring Wells

As part of Alternative 5, samples will be collected from at least 5 treatment monitoring wells for the purpose of monitoring the rate and extent of the treatment process. In addition, 20 long-term monitoring wells will be sampled and analyzed to monitor the production and extent, if any, of downgradient treatment products and the extent and nature of the current groundwater plumes. Samples will be collected before, during and following the treatment process. The samples will be submitted to an EPA approved laboratory for analysis. For purposes of this FS, it is assumed that the long-term monitoring samples will be analyzed for VOCs and inorganics on a semi-annual basis.

Data and statistical reviews would be performed every fifth year, for a period of 30 years or less, if contaminant levels in groundwater decrease significantly as a result of the treatment of the residual plume. The purpose of the reviews is to evaluate site status, assess the continued adequacy of the remedial activities, and to determine whether further action is necessary.

Component 4: Institutional Controls

This component is the same as Component 5 of Alternative 3.



LEGEND

(shaded area)	=	PROPOSED AREA FOR IN-SITU TREATMENT
(double dashed line)	=	FARM LANES (UNPAVED)

NOTES:

1. ISOPLETHS ARE FOR TCE IN THE INTERMEDIATE AQUIFER.
2. THIS IS A PRELIMINARY CONCEPTUAL DESIGN. FINAL DESIGN TO BE DETERMINED DURING DESIGN INVESTIGATION.

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DRAWN BY EEH/LDL DATE 10/3/00	Tetra Tech NUS, Inc.	ALTERNATIVE 5 IN-SITU TREATMENT OF ON-SITE RESIDUAL/HOT SPOT PLUME CROSSLEY FARM HEREFORD TOWNSHIP, BERKS COUNTY, PA	CONTRACT NO. 7525
CHECKED BY DATE			OWNER NO. 1210
REVISED BY DATE			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4-8 REV.

4.1.6 Alternative 6 – Residual/Hot-Spot Plume Pumping and On-Site Treatment/Recharge

This alternative addresses remediation of the residual or possible DNAPL (hot spot) area of on-site groundwater contamination. This area of contamination exists below the former borrow pit and immediately downgradient in a southerly direction towards existing wells HN-19, HN-20 and HN-23. For purposes of this FS it was assumed that the residual TCE contamination extends to a depth of about 400 feet and measured concentrations range up to 190,000 ug/L. Prior to the actual implementation of any remedial measures in this area, additional groundwater sampling and aquifer characterization will be required to delineate the complete vertical and horizontal extent of contamination and to visually determine if a DNAPL exists. The intent of this alternative is to capture a majority of the residual material within the on-site plume, however, implementation of this alternative may be conducted in a phased approach to minimize additional downgradient movement of the plume.

Under this alternative there are six main components: (1) pre-design investigation and treatability studies, (2) installation of well(s) for extraction of groundwater from the residual or DNAPL (hot spot) plume, (3) treatment of residual extracted groundwater for removal of the primary contaminants of concern, (4) recharge of the treated water to the on-site groundwater aquifer, (5) institutional controls, and (6) periodic monitoring of groundwater to determine the effectiveness of the treatment alternative and to monitor groundwater quality both on-site and off-site.

Component 1: Pre-Design Investigation and Treatability Studies

Pre-design investigations, including a pump-test and sampling and analysis of groundwater within the residual/hot spot plume area need to be conducted to provide information regarding the underlying aquifer characteristics. The information would be used for the selection of the appropriate treatment processes and design of the extraction and on-site re-injection systems. The pump test would be used to define the hydraulic conductivity, transmissivity, hydraulic gradient, etc. of the aquifer below the former borrow pit. Groundwater elevation monitoring and physical analysis of aquifer materials will also be required. Testing will be conducted in that area of the site where the extraction wells would be located and where re-injection of treated water would occur. One or more additional wells may be required for the pump test and groundwater elevation monitoring. Data obtained during the pre-design investigation will also be used following design of the extraction system to conduct fate and transport analysis for determination of the length of treatment required to achieve the RAOs and PRGs.

To aid in the design of an effective groundwater treatment system, extracted groundwater, representative of that which will ultimately be pumped through the treatment system, would be collected during the pump test(s) and analyzed for design related parameters including the COCs, TDS, TSS, pH, and certain inorganics (iron, manganese).

Component 2: Installation of Groundwater Extraction Wells

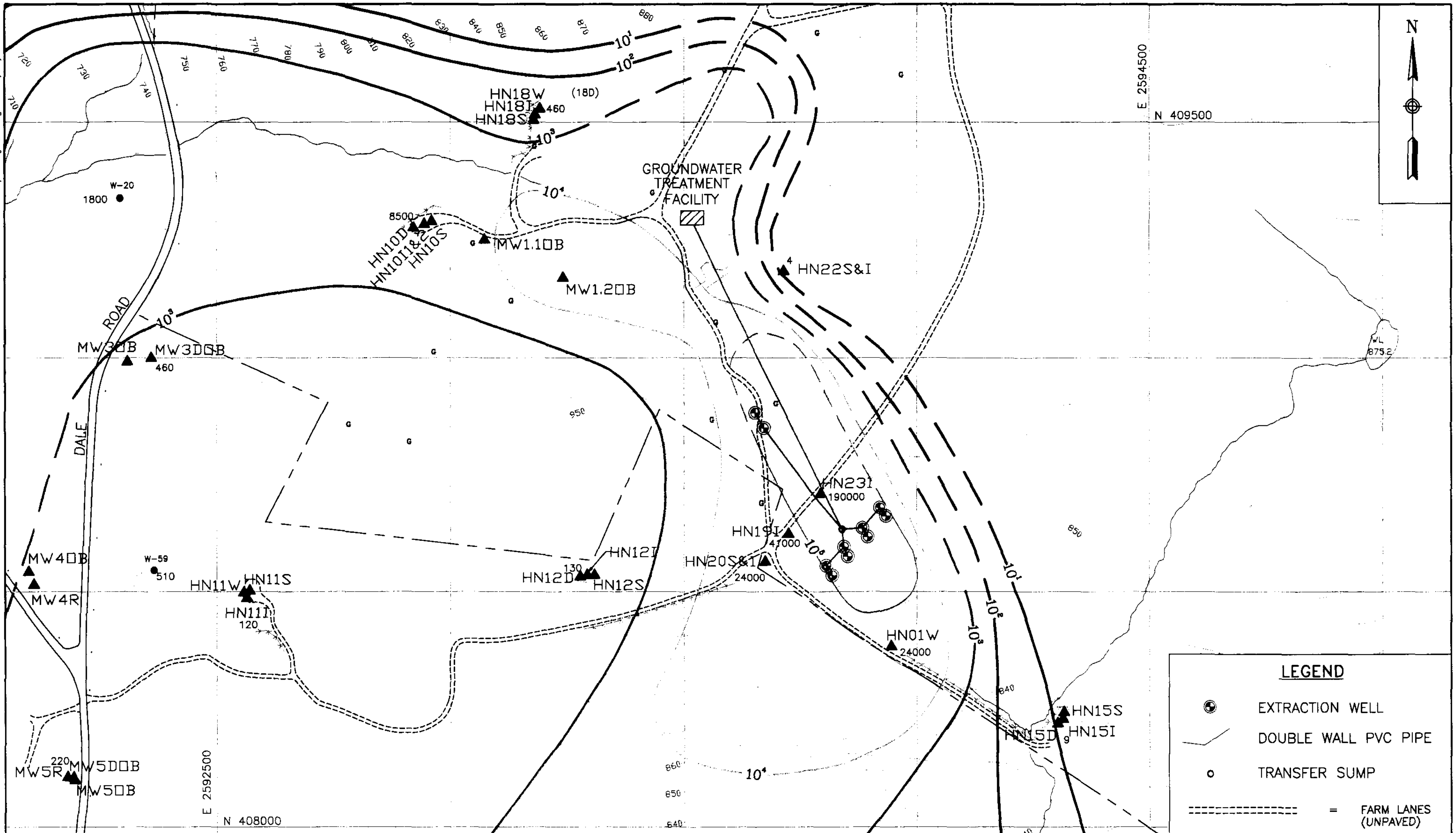
This component would consist of the installation of well(s) for withdrawal of water from the residual/hot spot plume. For purposes of this FS, preliminary calculations were performed to determine the number of wells needed for collection of the majority of the groundwater within the residual or DNAPL zone. Due to the possible location of residual material within the fractured bedrock underlying the former borrow pit, a less aggressive pumping approach (i.e., fewer wells pumping at a slower rate) may be equally as effective (see Appendix A). Based on information collected during the RI and preliminary calculations, a proposed extraction network was developed (see Figure 4-9). Two wells will be located within the borrow pit at depths of approximately 125 and 400 feet; another eight wells will be sited along the gravel road near existing wells HN-23, HN-19 and HN-20. Well depths of 125 and 400 feet are expected. The ten new wells would be pumped at rates ranging from about 5 gpm to 30 gpm to contain the residual plume. The contaminated groundwater would then be pumped to a possible on-site filtration unit and equalization tank. The filtration pre-treatment step is for the removal of suspended solids; equalization may be necessary to prevent upsets to the treatment process.

Component 3: Treatment of Residual Groundwater

Except for equipment sizing and GAC consumption, this component would be identical to Component 3 of Alternative 3. The final treatment technology will be selected based on data gathered during the pre-design investigation and any bench-scale treatability studies. For purposes of this FS, Component 3 would consist of installing an on site treatment system and operating this system for approximately 30 years. The treatment system would be housed in a 1,000 ft^2 pre-engineered and pre-fabricated building and consist of an equalization tank, a filter unit, and air stripper unit with off-gas treatment system, and a liquid-phase GAC adsorption unit. A typical PFD for this system is the same as for Alternative 3 (see Figure 4-4).

The equalization tank would be equipped with a mixer and sized at 1,500 gallons to provide approximately 30 minutes detention time under design flow conditions.

The equalized groundwater would be pumped by a 50 gpm centrifugal pump through the filter unit to the air stripper unit. The filter unit would be of the pressurized type and equipped with multiple disposable filter elements installed in parallel to allow for continued service during the periodic replacement of a clogged element. Clogged filter elements would be disposed of off site and replaced with fresh ones.



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CHECKED BY	DATE		RESIDUAL PLUME PUMPING AND ON-SITE TREATMENT/RECHARGE	OWNER NO. 1210	
REVISED BY	DATE		CROSSLEY FARM	APPROVED BY	DATE
SCALE AS NOTED			HEREFORD TOWNSHIP, BERKS COUNTY, PA	DRAWING NO. FIGURE 4-9	REV.

The equalized and filtered groundwater would then percolate down the packing of the column type air stripper unit and the air stripped groundwater would be collected in a sump at the bottom of the air stripper column. The air stripper unit would feature a 3-foor diameter column with 30 feet of loose packing and be equipped with a 550 cfm centrifugal blower to provide the necessary countercurrent of air.

Prior to exhausting to the atmosphere, the offgas exiting from the top of the air stripper column would pass through an off gas treatment unit. The off gas treatment unit would consist of an electric 7.5kW exhaust gas dryer followed by two vapor-phase GAC adsorption canisters, each holding 13,600 pounds of GAC and operating in series. It is estimated that the lead GAC adsorption canister would be replaced at least quarterly during the 30 years of operation.

The groundwater collected at the bottom of the air stripper unit would be conveyed by a 50 gpm centrifugal pump to the liquid-phase GAC adsorption unit. This unit would consist of two canisters, each holding 5,000 pounds of GAC and operating in series. No replacement of either the lead or lag liquid-phase GAC adsorption canisters in anticipated to be necessary during the 30 years of operation of the treatment system. Both of these canisters would feature backwash capabilities to deal with potential long-term accumulation of suspended solids in the GAC beds.

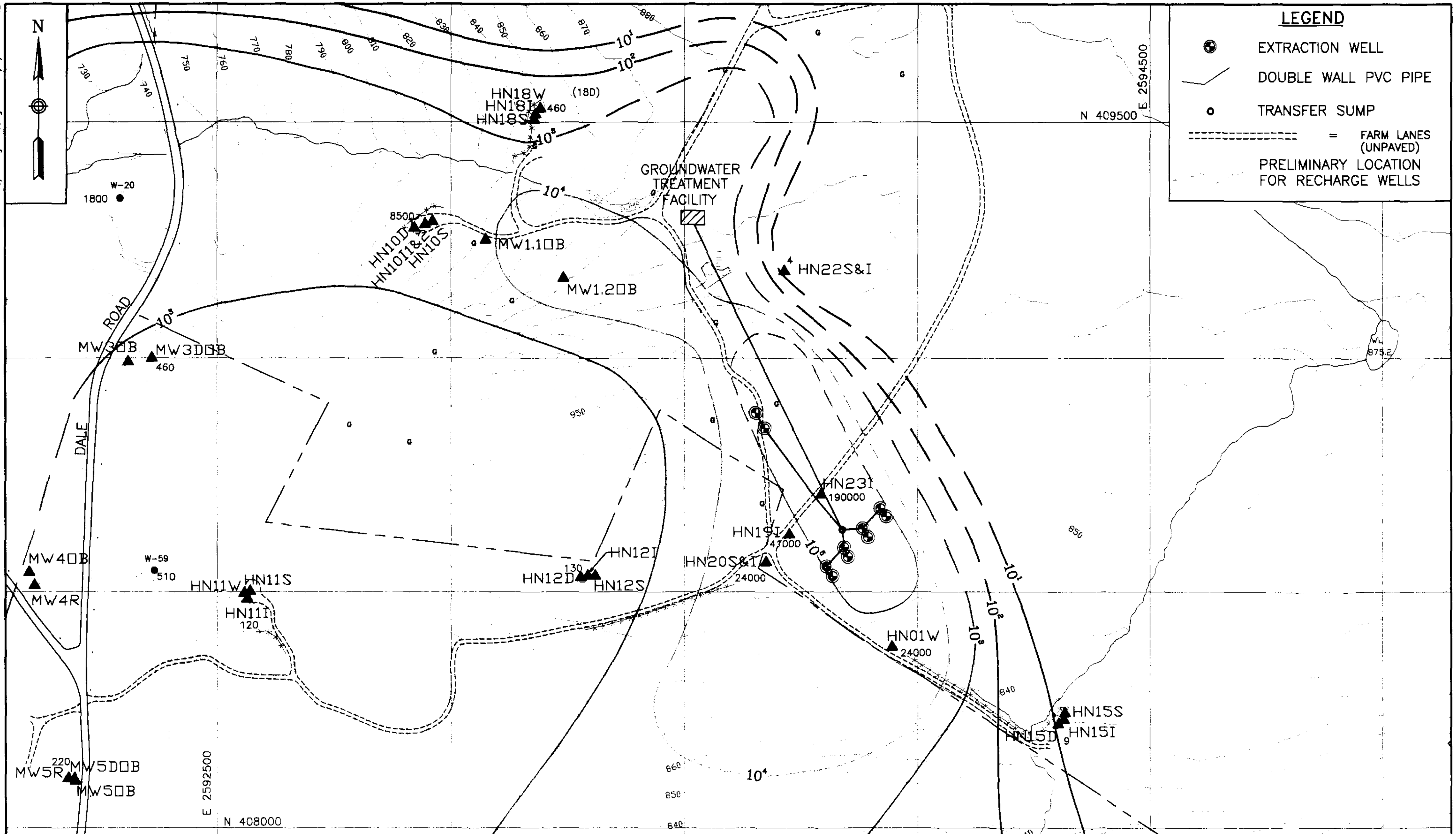
Performance of the treatment system would be monitored. Performance monitoring would consist of collecting monthly water samples from the inlet and outlet of the treatment system and analyzing these samples for chlorinated VOCs, iron, manganese, and TSS. Performance monitoring would also consist of collecting quarterly gas samples form the outlet of the lead GAC adsorption unit of the air stripper offgas treatment system and analyzing these samples for chlorinated VOCs.

Component 4: Recharge of Treated Groundwater On-Site

This component would consist of the discharge of the treated groundwater to on-site groundwater by discharge into several wells screened in the shallow and intermediate water-bearing zones. Based on preliminary calculations provided in Appendix A, the potential locations for the re-injection wells are shown on Figure 4-10. This component would also include regular monitoring and reporting of the quality of the discharge water.

Component 5: Institutional Controls

This component is the same as Component 5 of Alternative 3.



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CHECKED BY	DATE		PROPOSED RECHARGE SYSTEM LOCATION	OWNER NO. 1210
REVISED BY	DATE		CROSSLEY FARM	APPROVED BY / DATE
SCALE AS NOTED			HEREFORD TOWNSHIP, BERKS COUNTY, PA	DRAWING NO. FIGURE 4-10 / REV.

Component 6: Groundwater Monitoring

This component is the same as Component 6 of Alternative 3 except that groundwater samples would also be collected from within the residual plume to assess progress of the pump-and-treat system.

4.1.7 Alternative 7 - Groundwater Containment of Valley Plume, On-Site Treatment and Discharge to West Branch Perkiomen Creek

This alternative has been developed to address the plume of TCE contaminated groundwater that extends from the site downgradient into the valley north of West Branch Perkiomen Creek and eventually on the south side of the creek into Washington Township (see Figure 4-11). The intent of the remedial alternative is to capture contaminated groundwater originating from the site before it flows into or beneath the West Branch Perkiomen Creek or the unnamed tributary located along the east-southeast boundary of the plume. Similar to Alternative 3, the groundwater would then be treated ex-situ prior to discharge into the West Branch. The following paragraphs detail the remedial alternative components.

Component 1: Pre-Design Investigation and Treatability Studies

Pre-design investigations, including a pump-test(s) and sampling and analysis of groundwater, would be conducted to provide needed information regarding the underlying aquifer characteristics for the design of the extraction system. The pump test would be used to define the hydraulic conductivity, transmissivity, hydraulic gradient, etc. of the aquifer. The investigation would include at least one pump test, slug test(s) (possibly), groundwater elevation monitoring, and physical analysis of aquifer materials. Testing would be conducted in those areas of the valley where the extraction wells are expected to be located. Data obtained during the pre-design investigation will also be used to conduct fate and transport analysis for determination of the length of treatment to achieve the RAOs.

To aid in the design of an effective groundwater treatment system, extracted groundwater, representative of that which will ultimately be pumped through the treatment system, would be collected during the pump test(s) and analyzed for design related parameters including the site-specific VOCs, TDS, TSS, pH, alkalinity, hardness, TOC, COD, and certain inorganics (ex-iron, manganese). The collected water will also be used for bench-scale treatability studies as a preliminary step to the final design.

As a significant amount of groundwater may be pumped on a daily basis to capture the valley plume, groundwater flow modeling may be necessary to determine the effects of the pumping on any nearby private wells. A determination of the need for flow modeling should be made following review of the pump test and aquifer characterization data collected during the design phase. The pre-design investigation

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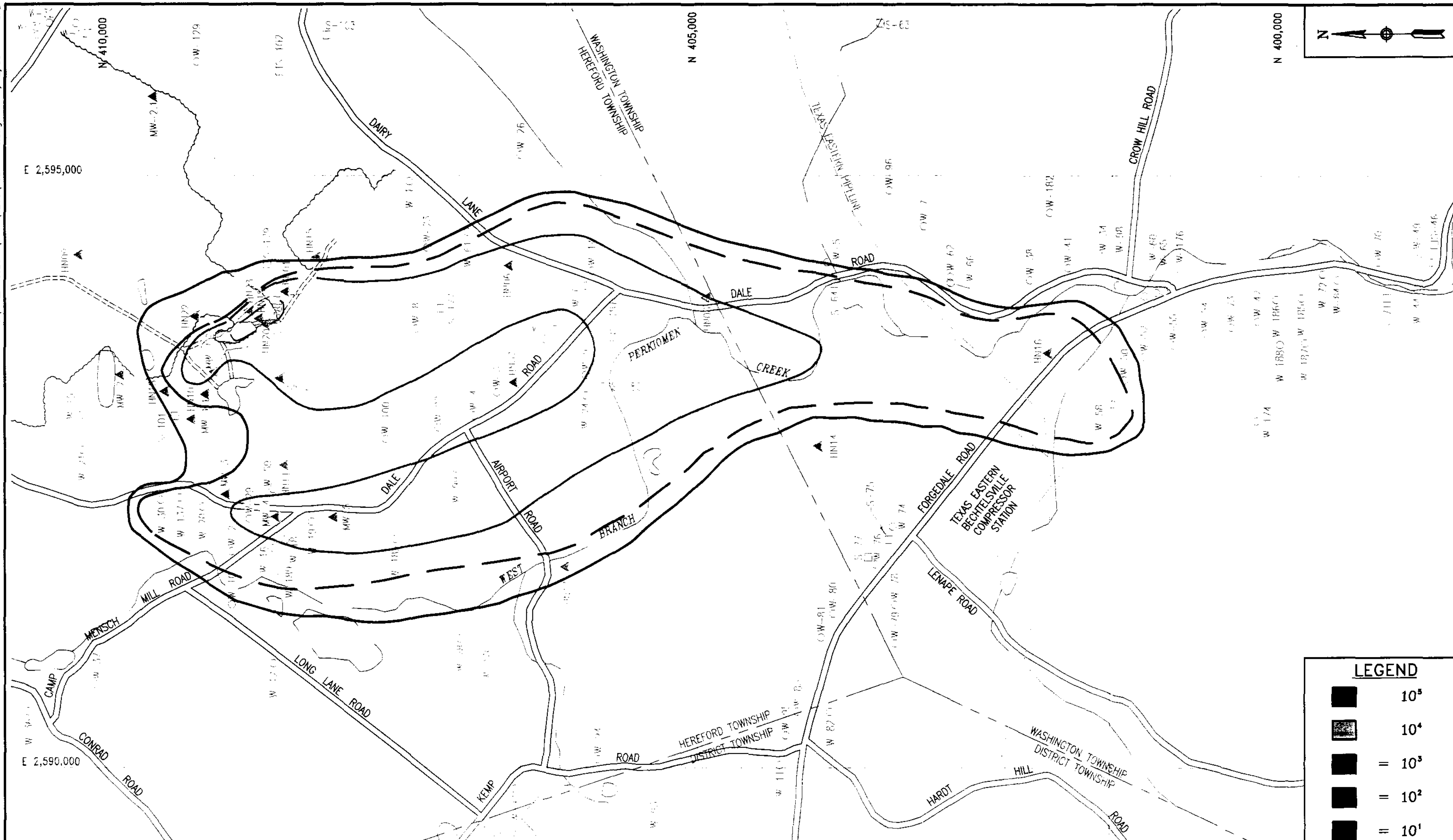

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CHECKED BY	DATE	Tetra Tech NUS, Inc.		OWNER NO. 1210	
REVISED BY	DATE			APPROVED BY	DATE
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would also include monitoring of the stream flow in the West Branch to determine current flow quantities. The data would then be used to determine the impact of the treated water quantities to the West Branch.

Component 2: Installation of Groundwater Well Network

This component would consist of a well network for containment of a portion of the valley plume prior to discharging into, or flowing beneath the West Branch Perkiomen Creek. The well network would be designed and operated to capture the 1,000+ ppb TCE contamination groundwater plume throughout the impacted intermediate and deep water-bearing zones (see Figure 4-12). Due to the size of the 10+ and 100+ ppb plumes and site access issues, capture of these plumes has not been proposed. For purposes of this FS, the O & M of the plume containment well network is expected to be for 30 years.

Based on information obtained during the RI and assumptions made regarding the hydraulic characteristics of the valley aquifer system, preliminary calculations were made to determine the number of wells needed (see Appendix A). To contain the eastern and western halves of the plume a total of 22 wells placed at depths up to 400 feet would be installed. The estimated total preliminary pumping rate is about 440 gpm. Equipment requirements would include submersible groundwater extraction pumps in each well and double-walled conveyance piping between wells to the treatment plant(s).

Component 3: Groundwater Treatment

This component is similar to Component 3 of Alternative 3. Due to the location of the extraction wells, the existing road network, and land access issues, the treatment component may consist of more than one plant system.

Based on a preliminary conceptual design for this FS, this component of Alternative 7 would consist of installing an on-site treatment system for each of the two Valley Plumes (East and West) and operating these two systems for a period of 30 years. Each groundwater treatment system would be housed in a 1,000 ft^2 pre-engineered and pre-fabricated building and consist of an equalization tank and a liquid-phase GAC adsorption system. The extracted groundwater would enter the treatment system in the equalization tank, flow through that tank and the liquid-phase GAC adsorption system and exit the treatment system to surface discharge. Preliminary process design calculations for the treatment system are provided in Appendix B.

The equalization tank would be equipped with a mixer and sized at 7,500 gallons to provide approximately 30 minutes detention time under design flow conditions.

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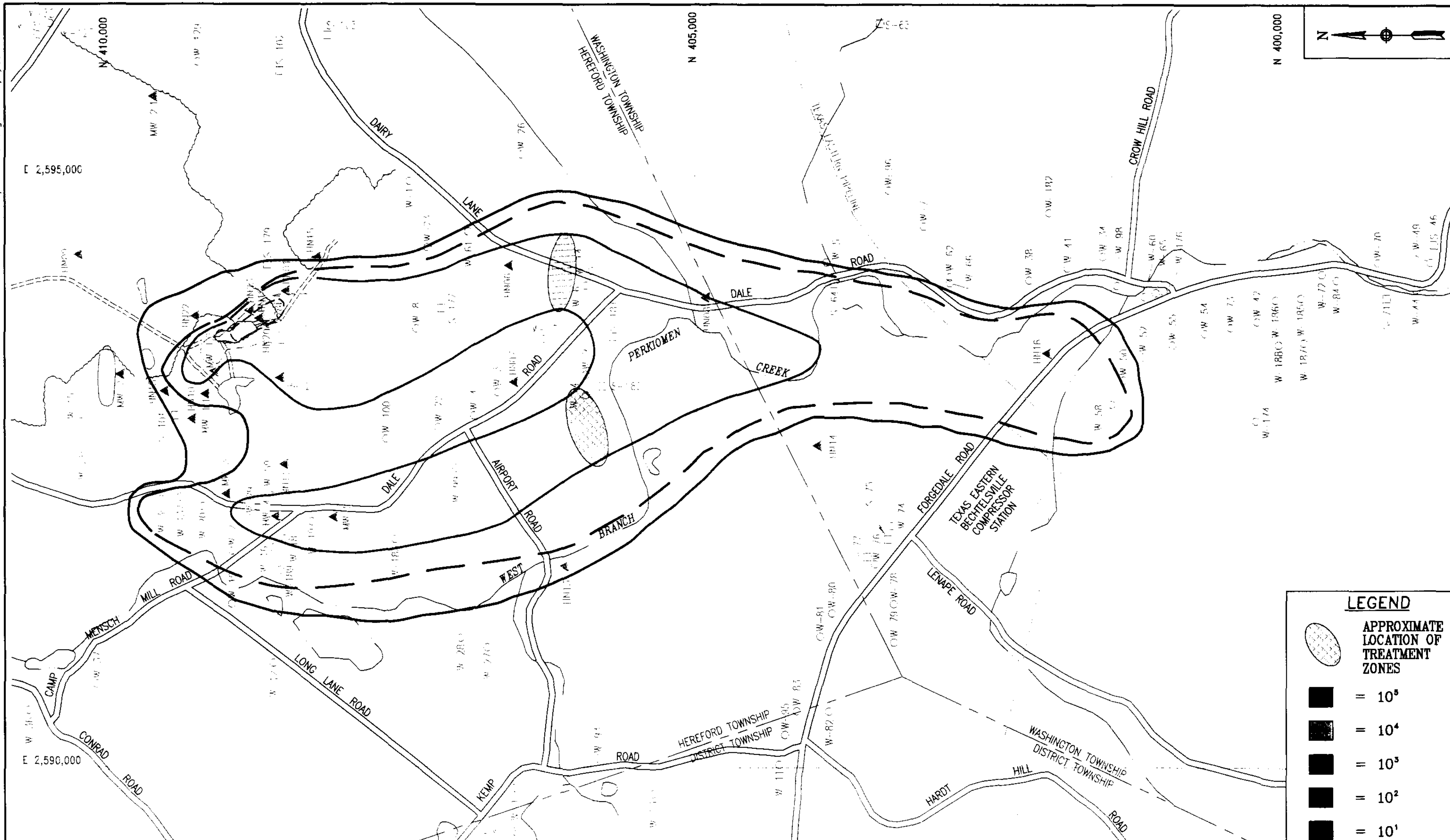

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CHECKED BY — DATE		GROUNDWATER CONTAINMENT OF VALLEY PLUME, ON-SITE TREATMENT AND DISCHARGE TO WEST BRANCH	OWNER NO. 1210
REVISED BY — DATE		CROSSLEY FARM	APPROVED BY — DATE
SCALE AS NOTED		HEREFORD TOWNSHIP, BERKS COUNTY, PA	DRAWING NO. FIGURE 4-12 — REV.

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The equalized groundwater flow would be pumped by a 250 gpm centrifugal pump to the liquid-phase GAC adsorption system. This system would consist of two units each holding 10,000 pounds of GAC and operating in series. Two replacements of the lead adsorption unit are anticipated to be necessary during the operating life of the treatment system, including one during the second and one during the tenth year of operation. The GAC adsorption units would feature backwash capabilities to deal with potential long-term accumulation of suspended solids in the GAC beds.

Performance of the treatment system would be monitored. Performance monitoring would consist of collecting monthly water samples from the inlet and outlet of the treatment system and analyzing these samples for chlorinated VOCs.

Component 4: Treated Water Discharge to West Branch Perkiomen Creek

This component would consist of the monitored discharge of about 440 gpm of treated water to the West Branch Perkiomen Creek. *Treated water upon exiting from the on-site treatment system would flow* through a buried single-wall pipeline from the site to a nearby location in the creek. The exact location would be determined during the RA design and would be based on proximity to the treatment system, site access, stream configuration, and cost to implement. The pre-design investigation would also include an *impact analysis on the addition of the treated water to the West Branch. The treated water will be* sampled on a periodic basis as it exits the treatment system prior to discharge. For purposes of this FS, approximately 200 feet of piping and one pump station will be required.

Component 5: Institutional Controls

As contamination will remain in groundwater beneath and downgradient of the site, institutional controls to restrict the use of site groundwater will be necessary. This component is the same as Component 5 of Alternative 3.

Component 6: Groundwater and Surface Water Monitoring

The monitoring component would consist of the periodic collection and analysis of samples from on-site and selected off-site well locations. Groundwater samples would be collected from within the valley plume to assess progress of the remedial efforts, downgradient of the extraction well network to evaluate contaminant migration, and from a number of the private well supplies to assess groundwater quality at impacted residences and businesses. Surface water samples downgradient of the extraction well network and treated water discharge point would also be collected to determine the effects of water withdrawal and discharge on the West Branch.

For purposes of this FS, monitoring would be performed over a period of 30 years and would consist of collecting samples from 20 locations. The samples will be analyzed for VOCs and inorganics. The sampling would be conducted on a semi-annual basis unless conditions changed requiring either an increase or decrease in sampling frequency.

Data and statistical analysis reviews will be performed every fifth year, for a period of 30 years, to evaluate site status, assess the continued adequacy of the remedial activities, and to determine whether further action is necessary.

The monitoring component would also include well maintenance. In case of change of site ownership during the course of the remedial activities, EPA and/or PADEP would meet with the new property owners to attempt to ensure that monitoring would continue.

4.1.8 Alternative 8 - In-Situ Treatment of Valley Plume

This alternative has been developed to address the plume of contaminated groundwater that extends into the valley located south and west of the site. The intent of Alternative 8 is the same as remedial Alternative 7, that is, to capture the contaminated groundwater originating from the site before it flows into or beneath the West Branch Perkiomen Creek or the unnamed tributary located along the east-southeast edge of the plume.

Under Alternative 8 there are four main components: (1) pre-design investigation and treatability studies, (2) treatment of contaminated groundwater within the valley plume using an appropriate in-situ technology, (3) sampling and analysis of treatment and long-term monitoring wells, and (4) institutional controls.

Component 1: Pre-Design Investigation and Treatability Studies

This component is similar to Component 1 of Alternative 5, except that all pre-design field investigations would be centered in the proposed area of remediation (see Figure 4-13) and would be directed towards the bench-scale and pilot testing for selection of an appropriate in-situ treatment technology for the intended treatment area.

Sampling and chemical analysis of groundwater and aquifer materials would be conducted to better define the chemical composition of the groundwater and aquifer materials. The data would be used to aid in the selection and design of an effective in-situ treatment system. To determine the length of treatment required to achieve the PRGs, further delineation of the residual or hot spot plume would be required, along with information regarding the efficiency of the selected treatment process.

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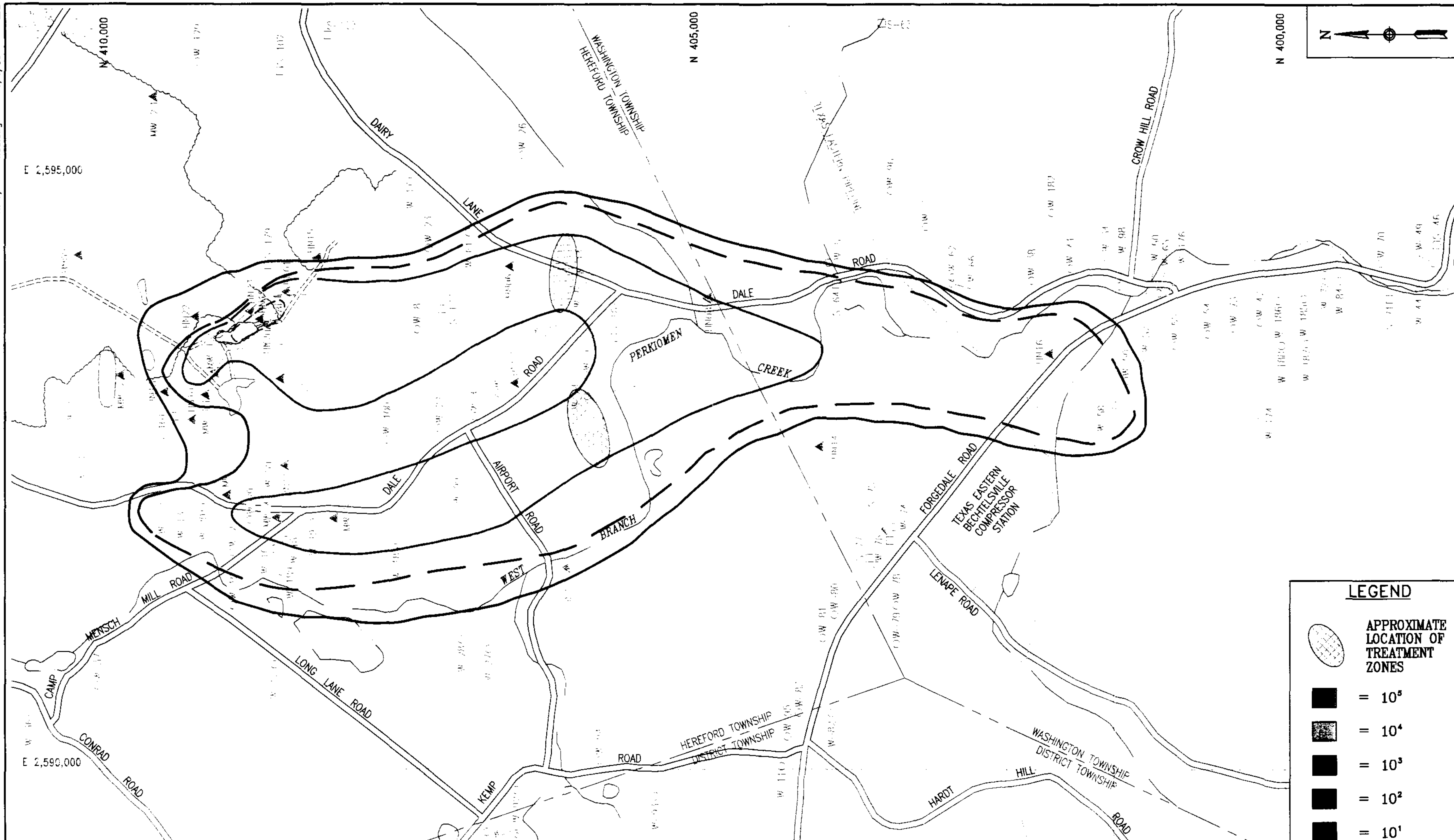

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CHECKED BY / DATE		IN-SITU TREATMENT OF VALLEY PLUME	OWNER NO. 1210	
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SCALE AS NOTED		HEREFORD TOWNSHIP, BERKS COUNTY, PA	DRAWING NO. FIGURE 4-13	REV.

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Component 2: In-Situ Treatment of Portion of Valley Plume

This component is the same as Component 2 of Alternative 5, except that treatment would be centered in those areas depicted in Figure 4-13. In-situ treatment would be conducted using an appropriate technology selected during the in-field pilot testing. The implementation of in-situ treatment would result in treatment of a portion of the valley plume. For purposes of this FS, it is assumed that in-situ treatment using chemical oxidation will be the selected process for Alternative 8. It is preliminarily estimated that 50 process injector wells, per treatment, curtain (100 wells total) and 12 treatment monitoring wells will be installed. The groundwater within the valley plume treatment zones (Figure 4-13) will be treated in-situ with a solution of potable water amended with oxidizers, catalysts and surfactants to effect a chemical reaction known as Fenton's Chemistry. The reaction results in the oxidation of complex organic contaminants, including TCE and PCE, to non-hazardous, naturally occurring acids that are further reduced to carbon dioxide, oxygen and water. Currently, several vendors have patented injection equipment or treatment agents. Selection of the appropriate technology and vendor will be based on the in-field testing during the RA pre-design phase.

Component 3: Sampling and Analysis of Treatment and Long-Term Monitoring Wells

As part of Alternative 8, samples will be collected from at least 12 treatment monitoring wells and 20 long-term monitoring wells. The purpose of the treatment monitoring program is to monitor the rate and extent of the treatment process and production and extent, if any, of downgradient treatment products. Samples will be collected before, during and following the treatment process. The purpose of the long-term monitoring program is to monitor the extent and concentration level of the on-site and off-site contamination that will remain. The sampling would be conducted on a semi-annual basis unless conditions changed requiring either an increase or decrease in sampling frequency. For purposes of this FS, it is assumed that the samples will be analyzed for VOCs and inorganics.

Data and statistical analysis would be performed every fifth year, for a period of 30 years, to evaluate site status, assess the continued adequacy of the remedial activities, and to determine whether further action is necessary.

The monitoring component would also include well maintenance. In case of a change of site ownership during the course of the remedial activities, EPA and/or PADEP would meet with the new property owners to attempt to ensure that monitoring would continue.

Component 4: Institutional Controls

This component is the same as Component 5 of Alternative 7.

4.1.9 Alternative 9 – Groundwater Containment of Center of the Plume and Valley Plume

The intent of this alternative is to remediate the plume of contaminated groundwater both in the upper area of Blackhead Hill (i.e., center of plume) and in the portion of the Dale Valley before it flows into or beneath the West Branch Perkiomen Creek or the unnamed tributary located along the east-southeast boundary of the plume. Under Alternative 9 there are six main components: (1) pre-design investigation and treatability studies; (2) installation of groundwater well systems for the hydraulic containment of the center of plume and the valley plume, (3) groundwater treatment, (4) treated water discharge to West Branch Perkiomen Creek, (5) institutional controls, and (6) groundwater and surface water monitoring.

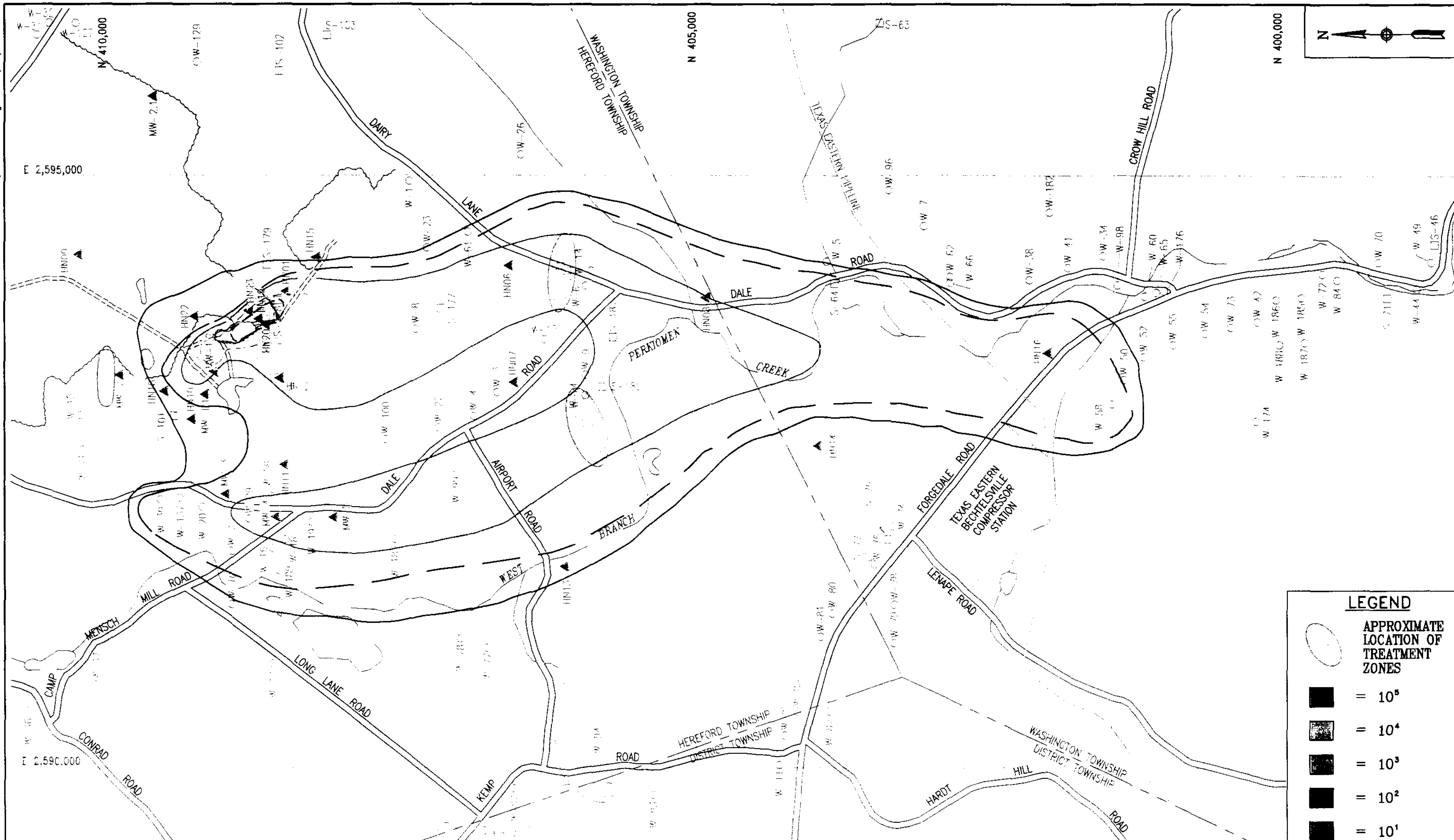
The implementation of Alternative 9 is dependent on the results of additional fieldwork to determine the effect on downgradient residential wells of the withdrawal, and off-site discharge of approximately 242 gpm from the upgradient aquifer. Approximately 440 gpm of groundwater from the Dale Valley area would also be pumped from the aquifer. As for Alternative 4, the additional field work and remediation modeling may not be required if a public water supply (i.e., water main) is provided to nearby downgradient residential well users. The following paragraphs detail the remedial alternative components.

Component 1: Pre-Design Investigation and Treatability Studies

This component would incorporate the field investigations and studies outlined under component 1 of Alternative 3 and component 1 of Alternative 7. The treatability studies would be adjusted as necessary to reflect the two areas of the plume.

Component 2: Installation of Groundwater Well Networks

Based on the pre-design investigations and engineering analysis, this component would consist of the installation of groundwater well networks for the capture of the 1,000 ug/L TCE contaminated groundwater plume present beneath Blackhead Hill and near the Dale Road and Dairy Lane intersection (see Figure 4-14). Due to the size of the 10+ and 100+ ug/L plumes, off-site property ownership issues, and the local topography, capture of these plumes has not been proposed for this analysis. Results from the proposed pre-design investigation may provide the needed data to design a system for the 10+ or 100+ ug/L plumes. For purposes of this FS, the O & M of the plume containment well network is expected to be 30 years. In addition, the number of proposed capture wells and pumping rates estimated for Alternatives 3 and 7 will be used for the analysis of Alternative 9.



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ALTERNATIVE 9

GROUNDWATER CONTAINMENT OF CENTER AND VALLEY PLUMES,
ON-SITE TREATMENT AND DISCHARGE TO WEST BRANCH
CROSSLEY FARM
HEREFORD TOWNSHIP, BERKS COUNTY, PA

CONTRACT NO. 7525	
OWNER NO. 1210	
APPROVED BY	DATE
DRAWING NO. FIGURE 4-14	REV.

Component 3: Groundwater Treatment

For purposes of this FS, it is assumed that this component is a combination of Component 3 of Alternatives 3 and 7.

Component 4: Treated Water Discharge to West Branch Perkiomen Creek

For purpose of this FS, it is assumed that this component is a combination of Component 4 of Alternatives 4 and 7.

Component 5: Institutional Controls

As contamination would remain for a period of time beneath and downgradient of the site, institutional controls to restrict the use of site groundwater will be necessary. Institutional controls would consist of deed notices or restrictions regarding the current and future use of groundwater on-site and/or off-site. The institutional controls would be in place until such time on-site groundwater levels are at or below the PRGs.

Component 6: Groundwater and Surface Water Monitoring

The monitoring component would consist of the periodic collection and analysis of samples from on-site and off-site well locations. Groundwater samples would be collected from the dissolved plume both the portion on Blackhead Hill (center of plume) and the Dale Valley area (valley plume). Samples will be collected to assess progress of the remedial efforts, downgradient of the extractions well networks to evaluate contaminant migration, and from a number of private well supplies to assess groundwater quality at impacted residences and businesses. Surface water samples downgradient of the extraction well network and treated water discharge point would also be collected to determine the effects of water withdrawal and discharge on the West Branch.

For purposes of this FS, monitoring would be performed over a period of 30 years and would consist of collecting samples from 20 locations. The samples will be analyzed for VOCs and inorganics. The sampling would be conducted on a semi-annual basis unless conditions changed requiring either an increase or decrease in sampling frequency.

Data and statistical analysis reviews will be performed every fifth year, for a period of 30 years, to evaluate site status, assess the continued adequacy of the remedial activities, and to determine whether further action is necessary.

The monitoring component would also include well maintenance, in case of change of site ownership during the course of the remedial activities; EPA and/or PADAP would meet with the new property owners to attempt to ensure that monitoring would continue.

5

5.0 DETAILED ANALYSIS OF ALTERNATIVES

The remedial alternatives developed in Section 4.0 are analyzed in accordance with the NCP and EPA guidance. The evaluation criteria according to the NCP are as follows:

- Overall protection of human health and the environment
- Compliance with ARARs and TBCs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

Under the NCP, the selection of the remedy is based on the nine evaluation criteria, which are categorized into three groups:

- Threshold Criteria – These criteria must be satisfied in order for an alternative to be eligible for selection. The threshold criteria are overall protection of human health and the environment and compliance with ARARs.

- Primary Balancing Criteria – The balancing criteria are used to weigh the relative merits of alternatives. The five criteria that are included are long-term effectiveness and permanence, the reduction of toxicity, mobility, or volume through treatment, short-term effectiveness, implementability, and cost.

- Modifying Criteria – State acceptance and community acceptance are considered to be modifying criteria that must be considered during remedy selection. These last two criteria cannot be evaluated in this FS until a preferred remedy has been presented.

Brief, general discussions of the evaluation criteria are presented in the following text. Detailed analyses of the remedial alternatives using seven of the evaluation criteria are presented in this section. Comparative analyses of the remedial alternatives are presented in Sections 6.0.

5.1 DESCRIPTION OF EVALUATION CRITERIA

Overall Protection of Human Health and the Environment

Alternatives must be assessed for adequate protection of human health and the environment. Overall protection draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. The evaluation focuses on whether a specific alternative achieves adequate protection, how risks are eliminated, reduced, or controlled, and whether remedial action objectives would be achieved.

Compliance with ARARs AND TBCs

Alternatives must be assessed to determine whether they attain applicable and appropriate requirements under Federal and state environmental laws or facility siting laws. If one or more regulations that are applicable cannot be complied with, then a waiver must be invoked. Grounds for invoking a waiver would depend on the following circumstances:

- The alternative is an interim measure and will become part of a total remedial action that will attain the ARAR.
- Compliance will result in greater risk to human health and the environment.
- Compliance is technically impracticable from an engineering perspective.
- The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach.
- A state requirement has not been consistently applied, or the state has not demonstrated the intention to consistently apply the promulgated requirement in similar circumstances at other remedial actions within the state.
- For Superfund-financed remedial actions, compliance with the ARAR will not provide a balance between the human health and the environment and the availability of Superfund money for response at other facilities.

EPA in consultation with PADEP, determines which ARARs are requirements.

Long-Term Effectiveness and Permanence

Alternatives must be assessed for the long-term effectiveness and permanence they offer, along with the degree of certainty that the alternative will prove successful. Factors that shall be considered as appropriate are:

- Magnitude of Residual Risk – Assesses the risk posed by untreated waste or treatment residuals at the conclusion of the remedial activities. The characteristics of residuals should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

- Adequacy and Reliability of Controls – Assesses controls such as containment systems and institutional controls that are necessary to manage treatment residuals or remaining untreated wastes and their reliability. In particular, the uncertainties associated with land disposal for providing long-term protection from residuals; the assessment for the potential need to replace technical components of the alternative; and the potential exposure pathways and risks posed should the remedial action need replacement.

Reduction of Toxicity, Mobility, or Volume through Treatment

The degree to which the alternative employs recycling or treatment that reduces the toxicity, mobility, or volume shall be assessed, including how treatment is used to address the principal threats posed by the site. Factors that shall be considered, as appropriate, include the following:

- The treatment processes that the alternative employs, the media they would treat, and threats addressed.
- The amount of hazardous substances, pollutants, or contaminants that will be destroyed, treated, or recycled.
- The degree of expected reduction in toxicity, mobility, or volume as a result of treatment.
- The degree to which the treatment is irreversible.
- The type and quantity of residuals that would remain following treatment, considering the persistence, toxicity, mobility, and bioaccumulation capacity of the contaminants of concern and impacted media.
- The degree to which treatment reduces the inherent hazards posed by principal threats at the site.

Short-Term Effectiveness

The assessment of short-term effectiveness during construction or implementation until the RAOs are met includes consideration of the following factors:

- Short-term risks that might be posed to the community during implementation
- Potential impacts to, and protection of, the workers during remedial actions.
- Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation.

- Time until the RAOs are achieved.

Implementability

The ease or difficulty of implementing the alternatives shall be assessed by considering the following types of factors, as appropriate:

- Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy.

- Administrative feasibility, including activities needed to coordinate with other offices and agencies, and the ability and time required obtaining any necessary approvals and permits from other agencies (for off-site actions).

- Availability of services and materials, including the availability of adequate off-site treatment, storage capacity, and disposal capacity and services, the availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources; the availability of services and materials; and availability of prospective technologies.

Cost

A detailed cost analysis is performed for each alternative to assess the net present-worth cost to implement the remedial action. The analysis includes an estimation of capital costs (direct and indirect), annual operation and maintenance (O&M) costs, and the net present value of the capital and O&M costs. Typically, the cost estimate accuracy range is plus 50 percent to minus 30 percent.

State Acceptance

PADEP has been providing input during the RI phase and will continue during the FS and public comment period. The state's concerns that must be assessed include the following:

- The state's position and key concerns related to the preferred alternative and other alternatives.
- State comments on ARARs or the proposed use of waivers.

These concerns cannot be evaluated at this time in the FS until EPA issues the proposed plan and the state has reviewed and commented on the RI/FS. State concerns may be discussed, to the extent possible, in the proposed plan to be issued for public comment.

Community Acceptance

This criterion refers to the community's comments on the remedial alternatives under consideration. Community concerns will be addressed after the public comment period, which follows the release of the RI/FS report and the proposed plan. As a result, this FS does not provide any discussion regarding the community acceptance of any of the remedial alternatives.

5.2 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES - GROUNDWATER

5.2.1 Alternative 1 - No Action

The no action alternative was developed as a baseline to which other alternatives may be compared as required by the NCP. No remedial activities or measures to reduce contaminant concentrations are proposed under Alternative 1.

Overall Protection of Human Health and the Environment

Alternative 1 would not provide protection of human health and the environment. Under the current land use, residential and agriculture, human and ecological exposure to contaminated groundwater would remain. Contaminants in the center of the plume would continue to migrate and impact on-site surface water springs, off-site residential drinking water wells and springs, and surface water bodies (i.e., West Branch Perkiomen Creek). No actions would be taken to prevent future use of site groundwater. The residual plume or possible DNAPL area would continue to act as a "source" of contaminants to the center of the plume. Carcinogenic and non-carcinogenic risks exceeding 1E-4 and a Hazard Index of 1.0, respectively, would remain for the use of on-site contaminated groundwater. Groundwater contaminants would remain at levels above MCLs in both the center of the plume and the residual plume, thereby posing continued risks to human health and the environment.

Compliance with ARARS and TBCs

This alternative would not comply with chemical-specific ARARs or TBCs as no action would be taken to reduce contaminant concentrations. Groundwater contaminant levels beneath the site would continue to exceed Federal and State drinking water criteria and no actions would be taken to restrict use or obtain a waiver for Technical Impracticability of Ground Water Restoration. No action- or location-specific ARARs or TBCs are applicable as no remedial actions would be taken.

Long-Term Effectiveness and Permanence

Alternative 1 would have no long-term effectiveness and permanence because contaminated groundwater would remain. As there would be no institutional controls to limit aquifer use or prevent further development, the potential would exist for additional unacceptable risk to human receptors. Although on-site and off-site contaminant concentrations might eventually decrease through natural attenuation the process would take many years.

No controls would be used to manage site contaminants under the No Action Alternative; therefore, the evaluation of the adequacy and reliability of controls is not applicable.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 1 would not reduce the toxicity, mobility, or volume of contaminants through treatment since no treatment would occur. Some reduction of contaminant toxicity or volume might occur through natural dispersion, dilution, or other attenuation processes.

Short-Term Effectiveness

Since no remedial action would occur, implementation of the no-action alternative would not pose any additional short-term risks to the local community or to on-site workers (i.e., farm workers) or livestock. There would be no additional impacts to the environment if Alternative 1 is implemented. The remedial action objectives would not be achieved and the groundwater PRGs would not be met.

Implementability

Since no remedial actions or measures would occur, Alternative 1 would be readily implementable. The technical feasibility criteria, including constructibility, operability, and reliability are not applicable. Additional actions can be implemented in the future, if necessary. Implementability of administrative measures is not applicable since no such measures would be taken. No permits would be required for implementation of Alternative 1.

Cost

No costs would be associated with the implementation of Alternative 1.

5.2.2 Alternative 2 - Institutional Controls and Groundwater Monitoring

Alternative 2 includes the development and implementation of institutional controls, such as permitting and deed notices for groundwater use on-site. Long-term, bi-annual sampling and analysis would be conducted to monitor the nature and extent of the center of the plume and residual zone. Site conditions and risks would be reviewed every five years.

Overall Protection of Human Health and the Environment

Alternative 2 would provide some protection of human health because on-site groundwater withdrawal and use would be regulated by Hereford Township or the Berks County Board of Health. EPA would provide assistance to the appropriate agency in setting up the institutional controls. This monitoring would include restrictions and/or requirements regarding the construction, placement, and operation, including pre-treatment, of any drinking water or agricultural use wells. Restrictions on possible future development of the site to non-agricultural use would also be implemented. Sampling and analysis of groundwater would be conducted to provide information regarding the extent and distribution of contaminants. Groundwater that is pumped from any of the regulated wells, treated, and then returned to the environment would provide some protection, though very little, of the environment. The remaining untreated groundwater would continue to flow off-site to downgradient groundwater users and to on-site and off-site springs and surface water bodies.

Groundwater monitoring would provide some protection by evaluating the nature and extent of the center of the plume. Monitoring would provide a warning so that appropriate measures could be implemented by downgradient water users.

Compliance with ARARs and TBCs

The implementation of institutional controls would result in some compliance with chemical-specific ARARs and TBCs as pre-treatment to drinking water standards would be required of any future water wells installed at the Crossley Farm. As no additional remedial actions or measures will be taken, groundwater concentrations within the center of the plume and residual zone will not comply with chemical-specific ARARs. The possible presence of DNAPL in a fractured bedrock environment makes compliance with chemical-specific ARARS and PRGs in the residual area very difficult if not achievable, from an engineering treatment standpoint. Location- and action-specific ARARs and TBCs will be complied with where pre-treatment is necessary.

Long-Term Effectiveness and Permanence

Alternative 2 would provide some long-term protection as restrictions and requirements for any current and future use of on-site groundwater would be in place. The restrictions would be implemented for as long as the on-site groundwater contaminant levels remain above the PRGs. Protection of human health would be dependent on adequate enforcement of the proposed groundwater use restrictions. Absence of adequate enforcement will result in carcinogenic and non-carcinogenic risk levels remaining the same until contaminant levels naturally attenuate. The site contaminants would continue to migrate off-site to downgradient users and to on-site and off-site springs.

Long-term monitoring of groundwater would allow the responsible agency to monitor the nature and extent of contaminants within the center of the plume and the residual zone. Five-year reviews would be required to assess whether human health risks are increasing or abating with time due to changes in the conditions at the site. Review of the effectiveness of the institutional controls and deed restrictions would also be required.

No difficulties or uncertainties are anticipated in performing the long-term monitoring. Groundwater monitoring wells are easily maintained and replaced if necessary. No controls would be used to manage site contaminants under Alternative 2; therefore, the evaluation of the adequacy and reliability of controls is not applicable.

Reduction of Toxicity, Mobility, or Volume through Treatment

The implementation of Alternative 2 would not result in the significant reduction of toxicity, mobility or volume of hazardous contaminants as treatment of groundwater within the center of the plume or the residual area would occur only if groundwater was withdrawn.

Short-Term Effectiveness

Alternative 2 would have minimal short-term effectiveness concerns. There would be no additional adverse impact on the surrounding community or the environment due to implementation. No PRGs would be achieved for the site groundwater.

Implementability

Alternative 2 could be implemented, though enforcement would be difficult. To implement, the Township or Board of Health would need to enact a deed restriction to restrict and/or regulate the use of site groundwater for drinking water or agricultural use. The Township or Board of Health would need to make periodic inspections to ensure that water used for human consumption was being treated properly. Implementation of the monitoring portion of Alternative 2 could be readily done as equipment and personnel to carry out the sampling are available. Regulatory personnel and environmental specialists are readily available to perform five-year reviews.

Cost

The costs associated with implementation of Alternative 2 would be related to the set-up and operation of a well permitting program for the site and the implementation of a routine groundwater monitoring program. A detailed cost estimate is provided in Appendix C. The estimated capital costs for Alternative 2 are $16,074. The average annual O&M costs are $21,900. The 5-year site reviews costs are $10,000 per event. Over a 30-year period, the net present worth cost is $581,148 (at a 7 percent discount rate).

5.2.3 Alternative 3 - Groundwater Containment of Center of Plume, On-Site Treatment/Recharge

Alternative 3 would result in the hydraulic containment of the 1,000 ug/L portion of the center of the dissolved plume. Prior to design and implementation of this alternative, a design investigation would be conducted to determine the most effective type of treatment (i.e., air stripping, carbon adsorption) and the type of extraction and re-injection system for the site aquifer conditions. For purposes of this FS, 23 wells would be installed to cutoff the plume in the westerly and southerly directions. The captured groundwater would be treated in an on-site treatment plant prior to discharge downgradient. Re-injection is proposed via a well system; for purposes of this FS, 46 wells are estimated to be used for the return of treated water to the aquifer. Institutional controls consisting of deed notices would be implemented for the site property to restrict and/or regulate the withdrawal and use of groundwater beneath the site. Long-term groundwater monitoring would be conducted to monitor the effectiveness of the containment and treatment systems and the nature and extent of the plumes.

A principal component of Alternative 3 is the design of the treatment system. As noted in Section 4.0, final design of the treatment system is dependent upon results obtained from the design field investigation. Both air stripping and carbon adsorption are proven technologies for the removal of chlorinated volatile organics like TCE and PCE. The following analysis assumes that air stripping with carbon polishing to achieve the PRGs will be suitable for the site contaminants and that their application will prove successful.

Overall Protection of Human Health and the Environment

The implementation of Alternative 3 would result in the overall protection of human health and the environment for site groundwater contaminated with TCE concentrations at or above 1,000 ug/L. Although contamination would continue to remain in the bedrock fractures within the residual area, extraction and treatment of contaminated groundwater along the leading edge of the 1,000 ug/L plume would result in a measurable level of protection to human health and the environment. It would prevent further expansion of the center of the plume and eventually achieve the PRGs along the leading edge. This would significantly reduce risk from exposure to contaminated groundwater and provide some protection to downgradient private wells. However, as the residual or DNAPL plume would not be significantly affected by the containment pumping, diffusion of the DNAPL contaminants into the shallow and intermediate aquifers would continue for many years, if not decades. Thus, the implementation of Alternative 3 may result in a treatment period of the same magnitude.

Institutional controls to be implemented during the treatment process would be protective of human health as they would result in the restriction of withdrawal and use of groundwater for drinking purposes from site wells. This should prevent unacceptable risks from exposure to groundwater contaminants. The effectiveness of the institutional controls would depend entirely upon enforcement of the restrictions. Future exposure to potential on-site contaminants in the groundwater would be prevented by restrictions on development of the property.

Long-term monitoring for the duration of the remediation period would make it possible to evaluate site conditions and risks and to determine the effectiveness and progress of the remedial actions. Groundwater monitoring would also be protective by evaluating the progress of remediation and detecting potential contaminant migration so that appropriate contingency measures can be taken if required.

Compliance with ARARs and TCEs

Alternative 3 will eventually comply with chemical-specific ARARs, such as MCLs along the leading edge of the center of the plume, though initially groundwater contaminated with TCE at levels below 1,000 ug/L would continue to migrate off the site. Alternative 3 will also comply with location-and action-specific ARARs, as the operation of the treatment system will be conducted in a regulatory approved manner. Within the residual area of the plume, ARARs will most likely not be achieved by implementation of this alternative due to the significantly elevated concentrations of TCE and possible presence of DNAPL. As a result, a Technical Impracticability (TI) waiver for remediation of groundwater at the site may be required.

Long-Term Effectiveness and Permanence

Based on the data collected during the RI and the assumption that no additional source areas are present on-site, the implementation of this alternative should achieve long-term effectiveness and permanence within the center of the plume. The technologies to be used for treatment of the contaminated groundwater are well proven and have been demonstrated to be effective in numerous field applications for long time periods. Although significant contamination will likely remain within the residual area providing a continual source of contamination, extraction and on-site treatment of contaminated groundwater will prevent expansion of the 1,000 ug/L plume and will eventually achieve the groundwater PRGs along the leading edge of the plume. The proposed alternative however, will not be effective in restoring the residual or DNAPL zone as the design of the extraction system will not result in the effective removal of contaminants from the bedrock fractures. Further information will be needed regarding the volume of residual TCE and PCE mass within the aquifer to determine the long-term effectiveness and performance of the implementation of this alternative on the residual zone.

Groundwater contaminated with TCE below 1,000 ug/L would continue to migrate from the site. Naturally occurring processes should effectively help to reduce contaminant concentrations in the aquifer over the long term.

The treated water will be returned to the aquifer downgradient of the collection wells. As the water will meet the PRGs there will be no adverse impacts to human health or the environment. Placement of the wells will be designed to maximize return flow but minimize increase in the normal water-table level. Re-injection is an effective method to return water to an aquifer and the reliability of the pumping and injection system is expected to be high. The process can be easily monitored and maintained. Routine maintenance and replacement of system components could be accomplished with minimal interruption to the operation of the system.

The implementation of institutional controls to restrict withdrawal and use of on-site groundwater would effectively prevent unacceptable risks of exposure to any future site activities during the treatment process.

Routine monitoring would be an effective means to evaluate the progress of remediation and to verify that no additional contaminant migration is occurring. Potential impacts to downgradient receptors and the need for any additional remedial measures can also be determined based on review of the monitoring data. The data will also be used to evaluate the performance of the alternative and on-site and off-site risks in the five-year review process. The five-year reviews will be required until on-site contaminant levels do not pose a potential risk to human health or the environment.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 3 when implemented would result in the reduction of the toxicity, mobility, and volume of a significant portion of the contaminated groundwater. Although the quantity of contaminants removed may decrease over time, the system will be designed to treat approximately 460,800 gallons per day (320 gpm) of contaminated groundwater with an initial average concentration of 1,000 ppb of TCE. The majority of contaminant removal is expected to occur within the first 5 years of treatment, however due to the possible presence of a DNAPL there will be a continuing source of contaminant release into the aquifer. For purposes of this FS, it has been assumed that the treatment system will operate continuously for a 30-year period. Over time, natural attenuation may supplement TCE and PCE removal by the pump-and-treat system.

If pre-treatment, such as filtration, is necessary prior to air stripping, some residual waste solids may be generated. These contaminants will be treated and/or destroyed off-site as needed.

The only air-stripping treatment residuals that would remain would be spent carbon from the aqueous phase carbon polishing unit and spent vapor phase carbon from treatment of gaseous emissions from the air stripper. Regeneration or incineration of the spent aqueous and vapor-phase GAC ensures that this reduction in contaminant toxicity and volume is completely irreversible.

Short-Term Effectiveness

The implementation of Alternative 3 would have minimal short-term effectiveness concerns. Exposure of workers to contaminants during the well installation, treatment system start-up and operation of the on-site treatment system would be minimized by wearing appropriate PPE and complying with site-specific health and safety procedures. No exposure to workers should occur during the operation of the on-site recharge system as the contaminated water will have been treated to levels not resulting in any potential risks.

Treatment of the air stripping off gases with GAC adsorption would reduce the risk to human receptors and workers by eliminating organic vapors from the emissions.

Implementability

Alternative 3 should be technically and administratively implementable. The installation of the wells can be accomplished using conventional well drilling equipment as the maximum depth of any of the extraction wells should be approximately 400 feet. The treatment equipment including pre-treatment filters, air stripping columns and GAC polishing units and GAC off-gas collectors are available from a number of vendors and can be made site-specific with minimal engineering effort. The construction of the on-site recharge system should utilize conventional equipment and materials and means of construction. Construction and start-up of the containment and treatment system should be fully implemented approximately 2 to 4 years after the ROD has been signed and approved by EPA.

Permits (manifests) will be required and obtainable for off-site transport and disposal of contaminated residues. As containment of the center of the plume will result in the withdrawal of approximately 500,000 gpd, coordination with the Delaware River Basin Commission (DRBC) will be required. As the water will be immediately returned to the aquifer following treatment, the permit for withdrawal and treatment should be obtainable.

An on-site recharge system for returning the treated groundwater to the site aquifer should be implementable, though some difficulty may be encountered due to the site geology and topography. The location of the concentrated portion of the plume on the downgradient side of Blackhead Hill and site access limitations are also issues of concern.

The implementation of deed notices regarding groundwater restrictions and the routine monitoring of groundwater are easily implementable. Experienced personnel are readily available for conducting five-year reviews as long as they are necessary.

Cost

The detailed cost estimate associated with implementation of Alternative 3 is outlined in Appendix C. The estimated costs are:

• Capital costs		$6,704,932
• Annual O&M Costs:	(Year 1)	$2,237,076
	(Years 2)	$1,625,076
	(Years 3)	$ 809,076
	(Years 4)	$ 523,476
	(Years 5-10)	$ 360,276

(Years 11-20)	$	278,676
(Years 21-30)	$	237,876

- Long-term Monitoring Costs (annual basis) $ 21,900
- Maintenance Costs (5-year basis) $ 15,000
- Five-year Reviews: $ 10,000

The 30-year net present worth is $14,609,180 based on a discount rate of 7 percent.

5.2.4 Alternative 4 - Groundwater Containment of Center of Plume, On-Site Treatment and Discharge to West Branch Perkiomen Creek

This alternative was developed to address site geology and off-site property ownership constraints that may be an issue with the locating of a suitable treated water recharge system (i.e., Alternative 3). Under this alternative piping would be installed to convey treated groundwater to a discharge point on the West Branch Perkiomen Cr00eek. All other components of this alternative are the same as for Alternative 3.

Overall Protection of Human Health and the Environment

The implementation of Alternative 4 would result in the protection of human health and the environment as site groundwater contaminated with TCE concentrations at or above 1,000 ug/L would be contained through pumping on-site. Contamination would remain for a period of time within the dissolved plume of TCE concentration less than 1,000 ug/l that exists off-site and downgradient into the valley. Over time Alternative 4 would prevent further expansion of the center of the plume and eventually achieve the PRGs along the leading edge. This would reduce risk from exposure to contaminated groundwater and provide protection to downgradient private wells. However, as the residual or DNAPL plume would not be significantly affected by the containment pumping, diffusion of the DNAPL contaminants into the aquifer would continue for many years, if not decades. Thus, the implementation of Alternative 4 may result in a treatment period of the same magnitude. The treated water would be discharged to the West Branch Perkiomen Creek. The implementation of this alternative would also result in reducing potential risk to exposure to contaminated surface waters that originated from site groundwater.

Institutional controls to be implemented during the treatment process would be protective of human health as they would result in the restriction of withdrawal and use of groundwater for drinking purposes from site wells. This should prevent unacceptable risks from exposure to groundwater contaminants. The effectiveness of the institutional controls would depend entirely upon enforcement of the restrictions. Future exposures to potential on-site contaminants in the groundwater would be prevented by restrictions on the development of the property.

Long-term monitoring for the duration of the remediation period would make it possible to evaluate site conditions and risks and to determine the effectiveness and progress of the remedial actions. Groundwater monitoring would also be protective by evaluating the progress of remediation and detecting potential contaminant migration so that appropriate contingency measures can be taken if required.

Compliance with ARARs and TCEs

Alternative 4 will eventually comply with chemical-specific ARARs, such as MCLs along the leading edge of the center of the plume, though initially groundwater contaminated with TCE at levels below 1,000 ug/L would continue to migrate off the site. Within the residual area of the plume chemical-specific ARARs would most likely not be achieved by implementation of this alternative due to the significantly elevated concentrations of TCE and the possible presence of a DNAPL. As a result, a TI waiver for remediation of groundwater at the site may be required. Alternative 4 would comply with the action-specific requirement under Title 29 of the Code of Federal Regulations for occupational safety and health since workers who install and perform maintenance of the treatment systems and workers who sample the long-term monitoring wells would conform with these requirements. The transport and disposal of spent activated carbon would be in compliance with the applicable portions of Resource Conservation and Recovery Act requirements (40 CFR Parts 262 and 263) and the applicable portions of the Hazardous Materials Transportation requirements (49 CFR 107, 171-179). Measures would be taken to safely remove and transport the spent carbon to a permitted facility for regeneration or incineration.

Long-Term Effectiveness and Permanence

Based on the data collected during the RI and the assumption that no additional source areas are present on-site, the implementation of this alternative should achieve long-term effectiveness and permanence for that portion of the plume where containment and treatment are proposed. The technologies to be used for treatment of the contaminated groundwater are well proven and have been demonstrated to be effective in numerous situations and for long time periods. A continual source of significant contamination will likely remain within the residual area. Hydraulic containment and on-site treatment of contaminated groundwater will prevent expansion of the 1,000 ug/L plume and will eventually achieve the groundwater PRGs, along the containment curtain. Long-term reliability of this alternative would be dependent on the proper O&M of the treatment system.

Naturally occurring processes will also effectively help to reduce contaminant concentrations in the aquifer over the long term. However, contaminants that are currently present in the less than 1,000 ug/L TCE plume would continue to migrate off-site and contaminant downgradient drinking water supplies. In addition, DNAPL material, if present, would continue to migrate thru bedrock fractures and channels and provide a continuing source of contaminants to bedrock groundwater.

The implementation of institutional controls to restrict withdrawal and use of on-site groundwater would effectively prevent unacceptable risks of exposure to any future site activities.

Long-term monitoring and the 5-year reviews would be required under Alternative 4 to assess the effectiveness and progress of the remedial measures to monitor the leading edge of the plume and to determine if additional response actions are needed to mitigate health risks.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 4 when implemented would result in the reduction of the toxicity, mobility and volume of the contaminated groundwater. Although the quantity of contaminants removed may decrease over time, the system will be designed to treat an estimated 460,800 gallons per day (320 gpm) of contaminated groundwater with an initial average concentration of 1,000 ppb of TCE. The majority of contaminant removal is expected to occur within the first 5 years of treatment, however due to the possible presence of a DNAPL there will be a continuing source of contaminant release into the aquifer. For purposes of this FS, it has been assumed that the treatment system will operate continuously for a 30-year period. Additional information on the DNAPL and its magnitude should be collected during the pre-design investigation. Regeneration or incineration of the spent GAC ensures that this reduction in contaminant toxicity and volume is completely irreversible.

Short-Term Effectiveness

The implementation of Alternative 4 would have minimal short-term effectiveness concerns. Exposure of workers to contamination during the well installation, treatment unit start-up and operation of the on-site treatment system would be minimized by wearing of appropriate PPE and complying with site-specific health and safety procedures. No exposure to workers should occur during the operation of the on-site recharge system as the contaminated water will have been treated.

Implementability

Alternative 4 should be technically and administratively implementable. The installation of the wells can be accomplished using conventional well drilling equipment as the maximum depth of any of the extraction wells should be approximately 125 feet. The Granular Activated Carbon treatment units are available from a number of vendors and can be made site-specific with minimal engineering effort. The construction of the on-site recharge system should utilize conventional equipment and materials and means of construction. Routine monitoring of groundwater is easily implementable.

Cost

The detailed cost estimate associated with Alternative 4 is contained in Appendix C. The estimated costs are:

• Capital costs		$6,339,215
• Annual O&M Costs:	(Year 1)	$2,234,529
	(Years 2)	$1,622,529
	(Years 3)	$ 806,529
	(Years 4)	$ 520,929
	(Years 5-10)	$ 357,729
	(Years 11-20)	$ 276,129
	(Years 21-30)	$ 235,329
• Long-term Monitoring Costs (annual basis)		$ 21,900
• Maintenance Costs (5-year basis)		$ 15,000
• Five-year Reviews:		$ 10,000

The 30-year net present worth is $14,211,857 based on a discount rate of 7 percent.

5.2.5 Alternative 5 - In-Situ Treatment of Residual Plume

This alternative will result in the reduction of contaminant concentrations within that area defined as the residual plume (i.e., beneath and immediately downgradient of the former borrow pit). Under this alternative an in-situ treatment technology will be selected based on the results of treatability studies conducted during the design investigation. The selected technology would then be used in the field for reduction of TCE and PCE concentrations beneath and adjacent to the borrow pit. Technologies which have been identified as potentially applicable to the site contaminants and conditions are chemical oxidation and air sparging/vacuum extraction.

Overall Protection of Human Health and the Environment

Implementation of Alternative 5 should result in some protection of human health and the environment due to the reduction in TCE and PCE concentrations.. The amount of TCE and PCE within the on-site residual zone should be reduced, thereby resulting in less contaminant mass available for diffusion into the dissolved plume and downgradient groundwater. However, as the extent of the residual plume and the degree of fractures within the bedrock beneath the borrow pit have not been characterized, long-term protection to human health and the environment afforded by implementation of Alternative 5 cannot be quantified. During the treatment process until remediation goals for site groundwater have been met, human health would be protected through use of institutional controls that would restrict use of untreated contaminated groundwater as drinking water. The effectiveness of this interim protection depends upon enforcement of the deed restrictions. Implementation of this alternative will not result in protection to human health and the environment within the center of the plume or valley plume (i.e., dissolved plumes) unless implementation of Alternative 5 results in almost complete destruction of the residual mass which is acting as a source of the dissolved plume.

Compliance with ARARs and TCEs

The implementation of Alternative 5 will not achieve the chemical -specific ARARs for the center of the plume and may not be effective for achieving MCLs within the residual plume unless all of the TCE and PCE mass within the residual plume zone can be effectively treated. Alternative 5 should meet applicable location-and action-specific ARARs.

Long-Term Effectiveness and Permanence

In-situ treatment involving chemical oxidation or air sparging/vacuum extraction has been shown to be an effective form of treatment for the destruction of TCE and PCE contaminants. The long-term effectiveness of the implementation of this alternative will be limited by the extent of contamination (i.e., ability to be reached by available injector equipment). Due to the presence of fractured bedrock within the study area, the implementation of Alternative 5 may not result in complete long-term effectiveness in achieving RAOs and PRGs within the residual zone.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 5 may be effective in the reduction of the toxicity, mobility, and volume of contamination within the residual zone of on-site groundwater. The degree of effectiveness cannot be determined, however, because of the limited data currently available (i.e., depth of contamination not known) and the fact that an unknown amount of contamination may reside within bedrock fractures. The waste products of the chemical oxidation treatment process are water, carbon dioxide, and oxygen so no further handling or treatment would be needed to further reduce the treatment by-products. Waste products produced from the air sparging/vacuum extraction process will include spent carbon from the vapor phase carbon polishing unit and possibly some condensed liquids. Any liquid wastes and adsorbed contaminants would be treated off site, which would permanently reduce their toxicity or mobility.

Short-Term Effectiveness

There could be risks to the community due to the fractured nature of the bedrock and limited knowledge regarding the orientation of the fractures beneath the former borrow pit and if any of these fractures connect to off-site drinking water supplies. If the fractures connect to downgradient drinking water supplies, the injection of an oxidizing agent could negatively impact current groundwater quality. Extensive fieldwork, including fracture analysis, would need to be conducted prior to the implementation of Alternative 5. Workers engaged in the installation of the injector wells and equipment may be exposed to elevated groundwater contamination. However, workers will be required to wear the appropriate PPE and follow a site-specific health and safety plan during all on-site activities that may involve potential exposure to site-related contaminants.

PRGs will not be achieved within the residual zone until sufficient contaminant mass is removed to reduce groundwater contaminant levels to MCLs. Within the dissolved or center of plume, RAOs and PRGs will not be achieved until the residual zone is completely treated, which may not be feasible from an engineering standpoint.

Implementability

The implementability of Alternative 5 will most likely be difficult due to the current knowledge of the extent of contamination and the presence of fractured and impervious bedrock within the residual zone of contamination. Based on data collected during the RI, the concentration of TCE appears to increase with depth in wells located immediately downgradient of the borrow pit (i.e., well couplets HN-01). The highest measure of TCE contamination to date is 190,000 ug/L in well HN-23 at a depth of 132 feet. The deepest concentration of TCE was found in well HN-01 at 263.5 feet. The concentration in well HN-01 was 36,000 ug/L. Both well HN-23 and HN-01 are located downgradient of the borrow pit.

Cost

The detailed cost estimate associated with Alternative 5 is contained in Appendix C. The estimated costs are:

- Capital costs! $7,593,660
- Long-term monitoring Costs (annual basis) $ 21,900

  Maintenance Cost (5-year basis) $ 15,000

  Five-year reviews: $ 20,000

The thirty-year net present worth is $8,212,634 based on a 7 percent discount rate.

5.2.6 Alternative 6 – Residual/Hot Spot Plume Pumping and On-Site Treatment/Recharge

The implementation of Alternative 6 should result in the capture of a portion of the residual or DNAPL zone of contamination located beneath the former borrow pit area. The number of wells and the rate of pumping are to be determined during the pre-design phase.

Overall Protection of Human Health and the Environment

Implementation of Alternative 6 should result in some protection of human health and the environment. The amount of TCE and PCE within the on-site residual zone should be reduced, thereby resulting in less contaminant mass available for diffusion into the dissolved plume and downgradient groundwater. However, as the extent of the residual plume and degree of fractures or DNAPL pooling areas within the bedrock beneath the borrow pit have not been characterized, the amount of protection to human health and the environment afforded by implementation of Alternative 6 cannot be well qualified, less alone quantified.

Compliance with ARARs and TCEs

The implementation of Alternative 6 will not achieve the chemical-specific ARARs for the center of the plume and may not be effective for achieving MCLs within the residual plume unless all of the TCE and PCE mass within the residual plume zone can be effectively treated. Alternative 6 should meet the location-and action-specific ARARs.

Long-Term Effectiveness and Permanence

Pumping and treatment of DNAPLs present in fractured bedrock has not proven to be an effective remedial methodology. As reported in Pankow and Cherry (1996), while significant quantity of annual mass extraction may occur in pump-and-treat situations, the fact that these systems have been operating for more than a decade at many DNAPL sites without appreciable concentration decline is evidence that a large ratio of source-zone mass to annual mass removed is typical at DNAPL sites. If in fact, DNAPL does exist beneath the borrow pit and the amount of material within the bedrock is significant, the long-term effectiveness of Alternative 6 is questionable.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 6 should be effective in the reduction of the toxicity, mobility and volume of contamination within the residual zone of on-site groundwater. The degree of effectiveness cannot be determined, however, based on the data currently available (i.e., depth of contamination not known) and the fact that an unknown amount of contamination may reside within bedrock fractures. Organic contaminants stripped during the treatment process would be discharged in the vapor or off-gas phase that will be removed by activated carbon scrubbing units. The spent carbon would be regenerated or incinerated depending upon the contaminants and waste concentrations.

Short-Term Effectiveness

During implementation of Alternative 6 there should be no short-term risks to the nearby community. Workers engaged in the installation of the extraction wells and pumping equipment may be exposed to elevated groundwater contamination. However, workers will be required to wear the appropriate PPE and follow a site-specific health and safety plan during all on-site activities that may involve potential exposure to site-related contaminants.

PRGs will not be achieved within the residual zone until sufficient contaminant mass is removed to reduce groundwater contaminant levels to MCLs. Within the dissolved or center of plume, RAOs and PRGs will not be achieved until the residual zone is completely treated, which may not be feasible from an engineering standpoint.

The recharge of treated water into the site aquifer should not pose any short-term effects.

Implementability

The implementability of Alternative 6 will most likely be difficult due to the known extent of contamination and the presence of fractured and impervious bedrock within the residual zone of contamination. Based on data collected during the RI, the concentration of TCE appears to increase with depth in wells located immediately downgradient of the borrow pit (i.e., well couplets HN-01). The highest measure of TCE contamination to date is 190,000 ug/L in well HN-23 at a depth of 132 feet. The deepest concentration of TCE was found in well HN-01 at 263.5 feet. The concentration in well HN-01 was 36,000 ug/L. Both well HN-23 and HN-01 are located downgradient of the borrow pit. Additional information on the depth, contaminant concentrations and bedrock characteristics needs to be obtained in order to better qualify the degree of technical feasibility of this alternative.

Cost

The detailed cost estimate associated with Alternative 6 is contained in Appendix B. The estimated costs are:

• Capital costs		$3,607,300
• Annual O&M Costs:	(Year 1)	$1,142,972
	(Years 2-3)	$ 571,772
	(Years 4-8)	$ 367,772
	(Years 9-15)	$ 203,649
	(Years 16-30)	$ 163,772
• Long-term Monitoring Costs (annual basis)		$ 21,900
• Five-year Maintenance and Reviews		$ 25,000

The 30-year net present worth is $8,649,466 based on a discount rate of 7 percent.

5.2.7 Alternative 7 – Groundwater Containment of Valley Plume, On-Site Treatment and Discharge to West Branch Perkiomen Creek

The implementation of Alternative 7 should result in the collection of contaminated groundwater located downgradient of the site prior to the groundwater discharging into or beneath the West Branch Perkiomen Creek. The collected groundwater would then be treated ex-situ prior to discharge into the West Branch.

Overall Protection of Human Health and the Environment

On-site human health and environmental receptors will not be protected by the implementation of Alternative 7 as the alternative would be implemented off-site and would not impact concentrations of hazardous constituents in site groundwater, soil, surface water, or sediment located upgradient of the area of influence of the proposed remedial scheme. The implementation of institutional controls at the site may provide some protection, if restrictions on the use of groundwater are enforced. However, the implementation of this alternative would result in protection to human health and environmental receptors located downgradient of the proposed implementation area as the groundwater would be collected and treated.

Long-term monitoring of groundwater would make it possible to evaluate site conditions and risks. In addition, the extent of the contaminant plume could be monitored. As contamination would remain on-site, five-year reviews by would need to be conducted.

Compliance with ARARs and TBCs

Alternative 7 when implemented would comply with ARARs and TBCs within the proposed groundwater remediation areas. However, as all contaminated groundwater at the site would not be subject to active treatment, ARARs and TBCs would not be complied with at the site. As a result, a TI waiver for remediation of groundwater at the site may be required.

Long-Term Effectiveness and Permanence

Alternative 7 will provide long-term protection of human health and the environment and would result in a permanent reduction in health risks within and downgradient of the area of application. On-site protection of human health would be dependent on enforcement of the proposed groundwater use restrictions. In absence of adequate enforcement, the current and future threats to human health from the groundwater would remain until the contaminants naturally attenuate.

Long-term monitoring of groundwater will provide information regarding the effectiveness of the groundwater containment and treatment system and the concentration and extent of the upgradient dissolve and residual groundwater plumes. Monitoring will also provide information if natural attenuation or degradation of the plumes is occurring and to what extent.

Reduction of Toxicity, Mobility or Volume through Treatment

The implementation of Alternative 7 will result in a reduction of toxicity, mobility and volume of the valley plume. Contaminants will be removed form the groundwater through the selected treatment process and the resulting waste stream (i.e., off-gas carbon or liquid phase activated carbon) would be incinerated or regenerated at an approved RCRA facility.

Short-Term Effectiveness

The implementation of Alternative 7 is not expected to pose any significant risks to remediation workers or the community. During construction, operation and routine maintenance of the groundwater collection and treatment facilities, workers would have to comply with a site-specific HASP, applicable OSHA requirements, and wear appropriate PPE. During construction and routine maintenance activities there would be a slight increase in traffic in order to provide construction and maintenance materials.

Implementability

Alternative 7 should be readily implementable, though access and land use agreements will need to be obtained from owners impacted by the construction and operation of the groundwater collection and treatment program. A number of vendors are available for installation of the pumping wells, piping, and treatment systems. Both air stripping and carbon adsorption are technologies which have been widely used for groundwater treatment for a number of years.

Several permits may be required if Alternative 7 is implemented. The DRBC may require approval for the withdrawal of the groundwater due to the amount needed to be pumped (i.e., in excess of 10,000 gpd). To allow for the discharge of the treated water to the West Branch Perkiomen Creek, state discharge requirements must be met. The transport and disposal of any spent carbon will be subject to RCRA regulations, including manifesting.

Long-term monitoring (sampling and analysis) requires readily available personnel and equipment. Regulatory personnel and environmental specialists are available to conduct five-year reviews that will be required as contaminants will remain at the site. Deed restrictions outlining the withdrawal and/or treatment of site groundwater should be implementable, though maybe difficult to enforce.

Cost

The detailed cost estimate associated with implementation of Alternative 7 is outlined in Appendix C.

• Capital Costs:	$5,366,997
• Annual O&M Costs (Years 1; 3-9, and 11-30)	$ 201,220
(Years 2 and 10)	$ 321,220
• Long-term Monitoring Costs (annual basis)	$ 21,900
Five-year Maintenance and Site Reviews	$ 25,000

The thirty-year net present worth is $8,627,074 based on a 7 percent discount rate.

5.2.8 Alternative 8 – In-Situ Treatment of Valley Plume

Overall Protection of Human Health and the Environment

On-site human health and environmental receptors will not be protected by the implementation of Alternative 8 as the alternative would be implemented off-site and would not impact concentrations of hazardous constituents in site groundwater located upgradient of the area of influence of the proposed remedial scheme. The implementation of institutional controls at the site may provide some protection, if restrictions on the withdrawal and treatment of groundwater are enforced. However, the implementation of this alternative would result in protection to human health and environmental receptors located downgradient of the proposed implementation area as the groundwater should be effectively treated in-situ.

Treatment monitoring will provide data to evaluate the effectiveness of the treatment system and to determine the presence and concentration of any by-product compounds. Long-term monitoring of groundwater would make it possible to evaluate site conditions and risks. In addition, the extent of the dissolved and residual contaminant plumes could be monitored. As contamination would remain on-site however, five-year reviews would need to be conducted.

Compliance with ARARs and TBCs

Alternative 8 when implemented should comply with ARARs and TBCs within the proposed groundwater remediation areas. The effectiveness of the treatment process will determine if the remedial alternative will comply with the chemical-specific ARARs. However, as groundwater at the site would not be subject to active treatment, ARARs and TBCs would not be complied with at the site or upgradient of the remedial alternative.

Long-Term Effectiveness and Permanence

Alternative 8 should provide long-term protection of human health and the environment and should result in a permanent reduction in health risks within and downgradient of the area of application. On-site protection of human health would be dependent on enforcement of the proposed groundwater use restrictions. In absence of adequate enforcement, the current and future threats to human health from the groundwater would remain until the contaminants naturally attenuate.

Long-term monitoring of groundwater will provide information regarding the effectiveness of the groundwater in situ treatment system and the concentration and extent of the upgradient dissolved and residual groundwater plumes. Monitoring will also provide information if natural attenuation or degradation of the plumes is occurring and to what extent.

Reduction of Toxicity, Mobility, or Volume through Treatment

The implementation of Alternative 8 will result in a reduction of toxicity, mobility, and volume of the valley plume. Contaminants will be chemically changed through the selected treatment process and there should not be any by-products that are hazardous constituents requiring further treatment.

Short-Term Effectiveness

The implementation of Alternative 8 is not expected to pose any significant risks to remediation workers or the community. During construction, operation and routine maintenance of the groundwater treatment facilities, workers would have to comply with a site-specific HASP, applicable OSHA requirements, and wear appropriate PPE. During construction and routine maintenance activities there would be a slight increase in traffic within the immediate vicinity of the site in order to provide construction and maintenance materials.

Implementability

Alternative 8 should be readily implementable, though access and land use agreements will need to be obtained from owners impacted by the construction and operation of the in situ treatment program. Several vendors are available for installation of the pumping wells, piping, and treatment systems.

Long-term monitoring (sampling and analysis) requires readily available personnel and equipment. Regulatory personnel and environmental specialists are available to conduct the five-year reviews as contaminants will remain at the site. Deed restrictions outlining the withdrawal and/or treatment of site groundwater should be implementable, though maybe difficult to enforce.

Cost

The detailed cost estimate associated with implementation of Alternative 8 is outlined in Appendix C.

- Capital Costs: $ 8,012,805
- Annual Treatment Costs: $ 1,437,500
- Long-Term Monitoring Costs (annual basis) $ 21,900
- Long-term Monitoring Costs (annual basis) $ 15,000
- Five-year Maintenance and Site Reviews $ 25,000

The 30-year net present worth is $26, 469,716 based on a 7 percent discount rate.

5.2.9 Alternative 9 – Groundwater Containment of Center of Plume and Valley Plume, On-Site Treatment and Discharge to West Branch Perkiomen Creek

Extraction well networks would be established within two areas of the 1,000 ug/L dissolved TCE contaminant plume, on Blackhead Hill within the center of plume and the Dale Valley near the intersection of Dale Road and Dairy Lane. Groundwater would be pumped to on-site treatment units where it would be treated such that the treated water would not contain contaminants in excess of MCLs and would not result in unacceptable carcinogenic and non-carcinogenic risks. The treatment systems would generally be composed of an equalization tank, a filtration system for suspended solids removal, an air stripper with an off-gas treatment unit and a final liquid-phase granular activated carbon adsorption polishing unit. The activated carbon would be replaced on a periodic basis or when breakthrough has been determined.

Through the provision of the treatment systems, organic contaminant concentrations would be reduced to the drinking water criteria (MCLs). Treated water would then be discharged to West Branch Perkiomen Creek at two locations. Institutional controls such as ordinances or deed restrictions may be used to prohibit the use of contaminated groundwater for drinking water use at impacted locations outside the proposed capture zone. Long-term monitoring for VOCs and metals would be used to determine the effectiveness of the extraction and treatment systems and to assess the status of the contaminant plume. As contaminants remain in the aquifer and would continue to pose threats to groundwater users, 5-year reviews would be conducted to assess site conditions and whether additional response actions are necessary.

Overall Protection of Human Health and The Environment

The implementation of Alternative 9 would provide a measurable level of protection of human health and the environment as groundwater contaminated with TCE above 1,000 ug/L would be captured and treated over a significant portion of the 1,000 ug/L plume. The system would not capture that portion of the plume with TCE concentrations less than 1,000 ug/L; that plume would continue to migrate and impact downgradient drinking water supplies. The proposed extraction networks should, however prevent further addition of contaminant mass into the lower concentration plumes.

Long-term reliability of the alternative to prevent exposures is dependent on the proper operation and maintenance of the treatment systems.

Deed restrictions could be used to prohibit the use of untreated contaminated groundwater at the site or impacted residences/business. The long-term monitoring program would provide the data necessary to determine the extent of the plume.

Compliance with ARARs and TCEs

Alternative 9 will eventually comply with chemical-specific ARARs, such as MCLs along the leading edge of the 1,000 ug/L center of plume and valley plume. For a period of time the groundwater plume with TCE concentrations less than 1,000 ug/L would continue to migrate from the site, downgradient through the Dale Valley. Eventually through, the extraction well network should prevent the release of additional site-related contaminants. Alternative 9 will also comply with location-and action-specific ARARs as all permit requirements would be met in the design and operation of the treatment systems. Within the immediate area of the DNAPL or residual "hot spot", ARARs may not be achieved by implementation of this ARAR. A TI waiver may need to be obtained as a complete remediation of the site groundwater can probably not be achieved.

LONG-TERM EFECTIVENESS AND PERMANCE

With the implementation of Alternative 9, overall carcinogenic and noncarcinogenic risks through exposure to contaminated groundwater could be expected to be reduced to within EPA's acceptable risk range, along the edge of the proposed areas of groundwater capture and treatment. Long-term reliability of this alternative would be dependent on the proper O&M of the treatment units to ensure effective removal of contaminants. The technologies to be used for treatment of the contaminated groundwater are well proven and have been demonstrated to be effective in numerous field applications for long time periods. Although significant contamination will likely remain with the residual area providing a continual source of contamination, extraction and on-site treatment of contaminated groundwater will prevent future expansion of the 1,000 ug/L plume. Naturally occurring processes should help to further reduce contaminant concentrations in the aquifer over the long term.

The treated water would be directly discharged to West Branch Perkiomen Creek at two locations. Sampling and analysis of the effluent would be conducted on a routine basis to monitor the quality of the water.

The implementation of institutional controls to restrict withdrawal and use of contaminated groundwater would effectively prevent unacceptable risk of exposure to future resident populations at the site during the treatment process.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 9 would result in the reduction of the toxicity, mobility, and volume of a significant portion of the groundwater plume. Initially, the center of plume system would treat about 320 gpm, while the valley plume systems would treat a total flow range of 400-450 gpm. The majority of contaminant removal is expected to occur within the first 5 years of operations; the level of removal for the remaining time period is dependent on the magnitude of the DNAPL area of the plume and amount of contaminant mass movement into the dissolved phase of the contaminated aquifer.

Residual materials generated by the treatment process, including spent carbon, wold be disposed of in a permitted and permanent manner.

Short-Term Effectiveness

The implementation of Alternative 9 would pose some short-term risk to the community during the construction of the remedial measures. There would be an increase in construction vehicle traffic and roads may be closed for a short time period when the various piping networks to the treatment systems or the creek are constructed. However, these actions should pose minimal hazards to the local community, as the establishment of proper construction traffic controls (i.e., signs and flags) would minimize the chance of accidents.

Exposure of workers to contaminants during the well installation, treatment system start-up and system operation would be minimized by wearing appropriate PPE and complying with site-specific health and safety procedures. Proper construction and industrial safety practices would be implemented during the construction of the treatment systems.

Implementability

Alternative 9 should be technically and administratively implementable. Prior to design and implementation however, groundwater modeling to determine the effects of the withdrawal of groundwater from the site would be required. The installation of the extraction wells can be accomplished using conventional well drilling equipment, as the maximum depth of any well should be about 400 feet. The treatment equipment including pre-treatment filters, air stripping columns and GAC polishing units and off-gas collectors are available from a number of vendors and can be made site-specific with minimal engineering effort. Construction and start-up of the containment and treatment systems should be fully implemented within 2 to 4 years after the ROD is signed and approved.

The implementation of deed notices regarding groundwater restrictions and the routine monitoring of groundwater are easily implementable. Experienced personnel are readily available for conducting five-year reviews as long as they are necessary.

Cost

The detailed cost estimate associated with the implementation of Alternative 9 is outlined in Appendix B. The estimated costs are:

• Capital Costs		$10,250,770
• O&M Costs	(Year 1)	$ 2,234,529
	(Year 2)	$ 1,622,592
	(Year 3)	$ 806,529
	(Year 4)	$ 520,929
	(Year 5-10)	$ 357,729
	(Year 11-20)	$ 276,129
	(Year 5-10)	$ 235,329

• Long-term Monitoring Costs (annual)	$	21,900
• Maintenance Costs (5-year basis)	$	30,000
• Five-year Site Review	$	10,000

The 30-year net present worth is $20,818,415 based on a 7 percent discount rate.

6

6.0 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

This section compares the analysis that were presented for each of the remedial alternatives in Section 5.0 of this FS. The criteria for comparison are identified to those used for the detailed analysis of individual alternatives.

The following remedial alternatives are being compared.

GROUNDWATER

- Alternative 1 — No Action
- Alternative 2 — Institutional Controls and Groundwater Monitoring
- Alternative 3 — Groundwater Containment of Center of Plume and On-Site Treatment/Recharge
- Alternative 4 — Groundwater Containment of Center of Plume and On-Site Treatment And Discharge to West Branch Perkiomen Creek
- Alternative 5 — In Situ Treatment of Residual Plume
- Alternative 6 — Residual/Hot Spot Plume Pumping and On-Site Treatment/Recharge
- Alternative 7 — Groundwater Containment of Valley Plume, On-Site Treatment and Discharge to West Branch Perkiomen Creek
- Alternative 8 — In Situ Treatment of Valley Plume
- Alternative 9 — Groundwater Containment of Center of Plume and Valley Plume, On-Site Treatment and Discharge to West Branch Perkimen Creek.

6.1 ALTERNATIVES COMPARISON - GROUNDWATER

The nine groundwater alternatives were compared to each other to identity differences between the alternatives. Table 6-1 summarizes the comparison of the analysis of alternatives.

6.1.1 <u>Overall Protection of Human Health and the Environment</u>

Alternative 1 would not provide any additional protection of human health and/or the environment since no action would be taken to reduce/eliminate site-related contaminant levels in site groundwater. No risk reduction is anticipated under the no-action alternative.

Alternative 2 would provide some additional protection of human health as institutional controls (i.e. deed restrictions) would be enacted to prevent and/or minimize any use of impacted on-site groundwater. The

TABLE 6 - 1
COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PA

CRITERION	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 INSTITUTIONAL CONTROLS AND MONITORING	ALTERNATIVE 3 CONTAIN, TREAT AND ON-SITE RECHARGE	ALTERNATIVE 4 CONTAIN, TREAT AND OFF-SITE RECHARGE	ALTERNATIVE 5 IN-SITU TREATMENT OF RESIDUAL/HOT SPOT PLUME	ALTERNATIVE 6 RESIDUAL/HOT SPOT PLUME PUMP AND TREAT, ON-SITE RECHARGE	ALTERNATIVE 7 GROUNDWATER CONTAINMENT OF VALLEY PLUME, ON-SITE TREAT AND OFF-SITE DISCHARGE	ALTERNATIVE 8 IN-SITU TREATMENT OF VALLEY PLUME	ALTERNATIVE 9 CONTAINMENT OF CENTER OF PLUME AND VALLEY PLUME, TREAT AND OFF-SITE DISCHARGE
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT									
Human Health	Provides no additional protection against human exposure to contaminated groundwater. Carcinogenic and non-carcinogenic risks exceeding EPA's target risk range would remain. No institutional controls to restrict use of untreated contaminated site groundwater for drinking water. No actions taken to reduce contaminant dispersion from center of plume, residual zone or valley plume.	Institutional controls would minimize potential exposure to site groundwater by prohibiting its use as drinking water. Groundwater monitoring would provide information regarding extent and concentration of contaminant plumes.	Over time will prevent exposure to TCE concentrations greater than 1,000 ug/l downgradient of site. Institutional controls would minimize potential exposure to site groundwater during the treatment period by prohibiting its use for drinking water. Monitoring would provide information regarding performance of remedial alternative and extent of untreated portion of site plume.	Same as Alternative 3.	Provides in-situ treatment of possible DNAPL source area. Natural degradation may reduce downgradient groundwater contaminant concentrations on-site and off-site, though over an extended period of time. Institutional controls and monitoring same as Alternative 3.	Provides collection and ex-situ treatment of possible DNAPL source area. Treated water would be returned on-site. Natural degradation may reduce groundwater contaminant concentrations on-site and off-site, though over an extended time period. Institutional controls and monitoring same as Alternative 3.	Would provide limited protection as majority of on-site and off-site plumes would not be contained and/or treated. Would provide collection and treatment of a portion of valley plume (>1,000+ug/l TCE). Institutional controls and monitoring same as Alternative 3.	Same as Alternative 7, however treatment may not reduce contaminant levels to below MCLs.	Would provide higher level of protection as groundwater contaminated with TCE >1,000 ug/l on Blackhead Hill and in Dale Valley would be captured and treated. Institutional controls and monitoring same as Alternative 3.

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TABLE 6 – 1
COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PA

CRITERION	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 INSTITUTIONAL CONTROLS AND MONITORING	ALTERNATIVE 3 CONTAIN, TREAT AND ON-SITE RECHARGE	ALTERNATIVE 4 CONTAIN, TREAT AND OFF-SITE RECHARGE	ALTERNATIVE 5 IN-SITU TREATMENT OF RESIDUAL/HOT SPOT PLUME	ALTERNATIVE 6 RESIDUAL/HOT SPOT PLUME PUMP AND TREAT, ON-SITE RECHARGE	ALTERNATIVE 7 GROUNDWATER CONTAINMENT OF VALLEY PLUME, ON-SITE TREAT AND OFF-SITE DISCHARGE	ALTERNATIVE 8 IN-SITU TREATMENT OF VALLEY PLUME	ALTERNATIVE 9 CONTAINMENT OF CENTER OF PLUME AND VALLEY PLUME, TREAT AND OFF-SITE DISCHARGE
COMPLIANCE WITH ARARs AND TBCs(continued)									
Location-Specific	Not applicable	Not applicable	Would comply	Would comply	Would comply	Would comply	May not comply	May not comply	May not comply
Action-Specific	Not applicable	Monitoring activities would comply with appropriate federal and state requirements.	Treatment processes for captured portion of plume would comply.	Same as Alternative 2.	Treatment processes for residual plume would comply.	Same as Alternative 5.	Treatment processes for portion of Valley plume would comply.	Same as Alternative 7.	Would comply
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT									
Treatment Process Used	None	None	Air Stripping with Activated Carbon Polishing	Same as Alternative 3.	Chemical Oxidation Using Fenton's Reagent	Same as Alternative 3	Same as Alternative 3.	Chemical Oxidation Using Fenton's Reagent	Same as Alternative 3
Amount Treated or Destroyed	None	None	Approximately 122 million gallons of contaminated groundwater, containing 1,018 lbs. TCE plus other VOCs remediated per year.	Same as Alternative 3.	Treatment of the residual source area (i.e., possible DNAPL) would result in the reduction of a portion of the TCE contaminated groundwater. Due to limited data on vertical and horizontal extent, quantity of contaminants removed/destroyed cannot be determined at this time.	Same as Alternative 5.	Treatment of a portion of the dissolved Valley plume would result in the reduction of some of the contaminated groundwater. Over an extended period of time the amount of contaminant mass removed from the plume would increase. No source reduction.	Same as Alternative 7.	Same as Alternative 3

CRITERION	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 INSTITUTIONAL CONTROLS AND MONITORING	ALTERNATIVE 3 CONTAIN, TREAT AND ON-SITE RECHARGE	ALTERNATIVE 4 CONTAIN, TREAT AND OFF-SITE RECHARGE	ALTERNATIVE 5 IN-SITU TREATMENT OF RESIDUAL/HOT SPOT PLUME	ALTERNATIVE 6 RESIDUAL/HOT SPOT PLUME PUMP AND TREAT, ON-SITE RECHARGE	ALTERNATIVE 7 GROUNDWATER CONTAINMENT OF VALLEY PLUME, ON-SITE TREAT AND OFF-SITE DISCHARGE	ALTERNATIVE 8 IN-SITU TREATMENT OF VALLEY PLUME	ALTERNATIVE 9 CONTAINMENT OF CENTER OF PLUME AND VALLEY PLUME, TREAT AND OFF-SITE DISCHARGE
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT (continued)									
Environment	No means of evaluating protection.	No additional protection provided to environmental receptors.	Over time would provide some protection as groundwater contaminant levels decreased.	Same as Alternative 3.	Over time would provide protection as source of contamination would be destroyed.	Same as Alternative 5.	Would not be protective of on-site ecological receptors.	Same as Alternative 7.	Same as Alternative 3
COMPLIANCE WITH ARARs AND TBCs									
Chemical-Specific	Would not comply with state groundwater quality standards or statutory requirements.	Same as Alternative 1.	Implementation of this alternative would result in containment and treatment of TCE dissolved plume of 1,000 ug/l or greater concentration. Treatment would achieve ARAR for captured groundwater, only. On-site and off-site TCE plumes less than 1,000 ug/l would not comply, though over extended time period concentrations should decrease.	Same as Alternative 3.	Dissolved plume would not comply; over time residual source would be removed; dissolved plume concentrations should decrease.	Same as Alternative 5. Extent of untreated portion of site plume.	On-site dissolved and residual groundwater plume concentrations would not be in compliance. Groundwater downgradient of valley treatment zone should comply over time.	Same as Alternative 7.	Would result in containment and treatment of TCE plume >1,000 ug/l. Lower concentrations plumes should comply over time.

TABLE 6 - COMPARA[illegible] ANALYSIS OF GROUNDWATER ALTERNATIVES
FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PA

CRITERION	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 INSTITUTIONAL CONTROLS AND MONITORING	ALTERNATIVE 3 CONTAIN, TREAT AND ON-SITE RECHARGE	ALTERNATIVE 4 CONTAIN, TREAT AND OFF-SITE RECHARGE	ALTERNATIVE 5 IN-SITU TREATMENT OF RESIDUAL/HOT SPOT PLUME	ALTERNATIVE 6 RESIDUAL/HOT SPOT PLUME PUMP AND TREAT, ON-SITE RECHARGE	ALTERNATIVE 7 GROUNDWATER CONTAINMENT OF VALLEY PLUME, ON-SITE TREAT AND OFF-SITE DISCHARGE	ALTERNATIVE 8 IN-SITU TREATMENT OF VALLEY PLUME	ALTERNATIVE 9 CONTAINMENT OF CENTER OF PLUME AND VALLEY PLUME, TREAT AND OFF-SITE DISCHARGE
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT (continued)									
Reduction of Toxicity, Mobility or Volume Through Treatment	No reduction, since no treatment would be employed.	Same as Alternative 1.	The groundwater extraction and treatment system would capture a portion of the dissolved plume and remove the VOCs to reduce the toxicity, mobility and volume of contaminated groundwater. Due to unknown quantity of source material beneath the borrow pit, the number of years of treatment to reduce on-site levels below ARARs is unknown.	Same as Alternative 3.	The toxicity and volume of untreated groundwater within the residual zone would be reduced through implementation of Alternative 5. The degree of reduction would be based on the level of effectiveness. Mobility of the residual plume not affected.	Same as Alternatives 5.	The toxicity and volume of groundwater within the valley plume would be reduced. Preliminary design would treat 2,400 gpm. Mobility of plume not affected.	Same as Alternative 7.	Same as Alternative 3 and 7.
Irreversible Treatment	Not Applicable	Not Applicable	Yes, contaminants are removed from groundwater.	Same as Alternative 3.	Yes, contaminants in groundwater are oxidized to non-toxic compounds.	Yes, contaminants are removed from groundwater.	Same as Alternative 6.	Yes, contaminants in groundwater are oxidized to non-toxic compounds.	Same as Alternative 3.
Statutory Preference for Treatment	No	No	Does not treat entire plume.	Does not treat entire plume.	Does not treat entire plume.	Does not treat entire plume.	Does not treat entire plume.	Does not treat entire plume.	Does not treat entire plume.

TABLE 6 - 1
COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PA

CRITERION	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 INSTITUTIONAL CONTROLS AND MONITORING	ALTERNATIVE 3 CONTAIN, TREAT AND ON-SITE RECHARGE	ALTERNATIVE 4 CONTAIN, TREAT AND OFF-SITE RECHARGE	ALTERNATIVE 5 IN-SITU TREATMENT OF RESIDUAL/HOT SPOT PLUME	ALTERNATIVE 6 RESIDUAL/HOT SPOT PLUME PUMP AND TREAT, ON-SITE RECHARGE	ALTERNATIVE 7 GROUNDWATER CONTAINMENT OF VALLEY PLUME, ON-SITE TREAT AND OFF-SITE DISCHARGE	ALTERNATIVE 8 IN-SITU TREATMENT OF VALLEY PLUME	ALTERNATIVE 9 CONTAINMENT OF CENTER OF PLUME AND VALLEY PLUME, TREAT AND OFF-SITE DISCHARGE
LONG-TERM EFFECTIVENESS AND PERMANENCE									
Magnitude of Residual Risk	Existing risks would remain.	Implementation and enforcement of institutional controls would reduce risks from exposure to on-site groundwater. Risks to off-site untreated groundwater would remain.	Groundwater treatment would result in reduction of risks from exposure to a portion of the on-site TCE plume. Over an extended period, until groundwater remediation goals are achieved and natural degradation reduces on-site concentrations, implementation and enforcement of institutional controls would reduce risks from exposure to on-site groundwater.	Same as Alternative 3.	Over time, risk at site would be reduced as source of contamination would be removed; however dissolved plume not treated.	Same as Alternative 5.	Risk at site would remain the same; risk downgradient of treatment zone would be reduced.	Same as Alternative 7.	Same as Alternative 3.

TABLE 6 – COMPARA[illegible]E ANALYSIS OF GROUNDWATER ALTERNATIVES
FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PA

CRITERION	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 INSTITUTIONAL CONTROLS AND MONITORING	ALTERNATIVE 3 CONTAIN, TREAT AND ON-SITE RECHARGE	ALTERNATIVE 4 CONTAIN, TREAT AND OFF-SITE RECHARGE	ALTERNATIVE 5 IN-SITU TREATMENT OF RESIDUAL/HOT SPOT PLUME	ALTERNATIVE 6 RESIDUAL/HOT SPOT PLUME PUMP AND TREAT, ON-SITE RECHARGE	ALTERNATIVE 7 GROUNDWATER CONTAINMENT OF VALLEY PLUME, ON-SITE TREAT AND OFF-SITE DISCHARGE	ALTERNATIVE 8 IN-SITU TREATMENT OF VALLEY PLUME	ALTERNATIVE 9 CONTAINMENT OF CENTER OF PLUME AND VALLEY PLUME, TREAT AND OFF-SITE DISCHARGE
LONG-TERM EFFECTIVENESS AND PERMANENCE (continued)									
Adequacy and Reliability of Controls	Not Applicable.	Long-term enforcement of institutional controls would be required to ensure their effectiveness for preventing use of contaminated groundwater.	Groundwater extraction and air stripping are widely used effective technologies for the remediation of VOC contaminated groundwater.	Same as Alternative 3.	Relatively new treatment process, may not be adequate for extent of DNAPL source area and contaminant levels; has had limited field applications.	Groundwater extraction and air stripping are widely used effective technologies for the remediation of VOC contaminated groundwater. Adequacy of treatment is dependent upon effectiveness of extraction/containment system.	Same as Alternative 6	Relatively new treatment process, has had limited field applications. Adequacy of treatment is dependent upon effectiveness of reagent versus contaminant levels and geology of treatment area.	Same as Alternative 3. and 6
Need For 5-Year Review	Review would be required since groundwater contaminants would be left in place.	Review would be required since groundwater contaminants would be left in place and institutional controls would be implemented.	Review would be required for the duration of the groundwater remediation period since groundwater contaminants would remain above remediation goals and institutional controls would be implemented.	Same as Alternative 3.	Review would be required since dissolved plume not remediated.	Same as Alternative 5.	Review would be required since source area and majority of dissolved plume not addressed.	Same as Alternative 7.	Same as Alternative 3.

CRITERION	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 INSTITUTIONAL CONTROLS AND MONITORING	ALTERNATIVE 3 CONTAIN, TREAT AND ON-SITE RECHARGE	ALTERNATIVE 4 CONTAIN, TREAT AND OFF-SITE RECHARGE	ALTERNATIVE 5 IN-SITU TREATMENT OF RESIDUAL/HOT SPOT PLUME	ALTERNATIVE 6 RESIDUAL/HOT SPOT PLUME PUMP AND TREAT, ON-SITE RECHARGE	ALTERNATIVE 7 GROUNDWATER CONTAINMENT OF VALLEY PLUME, ON-SITE TREAT AND OFF-SITE DISCHARGE	ALTERNATIVE 8 IN-SITU TREATMENT OF VALLEY PLUME	ALTERNATIVE 9 CONTAINMENT OF CENTER OF PLUME AND VALLEY PLUME, TREAT AND OFF-SITE DISCHARGE
SHORT-TERM EFFECTIVENESS									
Community Protection	No risk to community anticipated.	No significant risk to community anticipated.	No significant risk to community anticipated. Engineering controls would be used during implementation to mitigate risks.	Same as Alternative 3.	Risk to community should be minimal, additional information on bedrock fracture network and treatment process chemistry required prior to implementation.	No significant risk to community anticipated. Engineering controls would be used during implementation to mitigate risks.	Same as Alternative 6.	Same as Alternative 5.	Same as Alternative 3.
Worker Protection	No risk to workers anticipated if proper PPE is used during long-term monitoring.	Same as Alternative 1	No significant risk to workers anticipated if proper PPE is used during installation and operation of the groundwater extraction and treatment systems and long-term monitoring.	Same as Alternative 3.	No significant risk to workers anticipated if proper PPE is used during installation and operation of the in-situ treatment system and long-term monitoring.	Same as Alternative 3.	Same as Alternative 3.	Same as Alternative 5.	Same as Alternative 3.
Environmental Impacts	None anticipated since no remedial actions would be taken.	None anticipated as remedial measures consist of institutional controls and monitoring.	No adverse impacts to the environment anticipated during construction. Engineering controls would be used during implementation to mitigate risks	Same as Alternative 3.	Additional information on bedrock fracture network required prior to design and implementation to identify required engineering controls to minimize risk.	No adverse impacts to the environment anticipated. Engineering controls would be used during implementation to mitigate risks.	Same as Alternative 6.	Additional information on proposed treatment area geology and hydrogeology needed to identify required engineering controls to minimized risk.	Same as Alternative 3.

TABLE 6 -
COMPARA… ANALYSIS OF GROUNDWATER ALTERNATIVES
FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PA

CRITERION	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 INSTITUTIONAL CONTROLS AND MONITORING	ALTERNATIVE 3 CONTAIN, TREAT AND ON-SITE RECHARGE	ALTERNATIVE 4 CONTAIN, TREAT AND OFF-SITE RECHARGE	ALTERNATIVE 5 IN-SITU TREATMENT OF RESIDUAL/HOT SPOT PLUME	ALTERNATIVE 6 RESIDUAL/HOT SPOT PLUME PUMP AND TREAT, ON-SITE RECHARGE	ALTERNATIVE 7 GROUNDWATER CONTAINMENT OF VALLEY PLUME, ON-SITE TREAT AND OFF-SITE DISCHARGE	ALTERNATIVE 8 IN-SITU TREATMENT OF VALLEY PLUME	ALTERNATIVE 9 CONTAINMENT OF CENTER OF PLUME AND VALLEY PLUME, TREAT AND OFF-SITE DISCHARGE
SHORT-TERM EFFECTIVENESS (continued)									
Time Until Remedial Action Objectives Achieved	Not Applicable	1 year until RAO for preventing exposure to site groundwater is achieved. Would not meet RAO for preventing migration of contaminated groundwater.	Will achieve RAO for preventing exposure to site groundwater with 1 year (by institutional controls). Will not achieve RAO of preventing migration of contaminated groundwater as only a portion of the on-site dissolved plume will be contained (1,000+ppb TCE). As no source (i.e. DNAPL zone) removal would occur duration of pump-and-treat cannot be determined.	Same as Alternative 3.	Need additional information to determine.	Will achieve RAO for preventing exposure to site groundwater within 1 year (by institutional controls). Will not achieve RAO of preventing migration of contaminated groundwater as only a portion of the on-site dissolved plume will be captured for treatment (residual zone). Need to quantity source mass to determine duration of treatment.	Addresses only a portion of the valley plume (1,000+ppb TCE); does not address migration of site plume or source removal.	Same as Alternative 7.	Same as Alternative 3.

CRITERION	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 INSTITUTIONAL CONTROLS AND MONITORING	ALTERNATIVE 3 CONTAIN, TREAT AND ON-SITE RECHARGE	ALTERNATIVE 4 CONTAIN, TREAT AND OFF-SITE RECHARGE	ALTERNATIVE 5 IN-SITU TREATMENT OF RESIDUAL/HOT SPOT PLUME	ALTERNATIVE 6 RESIDUAL/HOT SPOT PLUME PUMP AND TREAT, ON-SITE RECHARGE	ALTERNATIVE 7 GROUNDWATER CONTAINMENT OF VALLEY PLUME, ON-SITE TREAT AND OFF-SITE DISCHARGE	ALTERNATIVE 8 IN-SITU TREATMENT OF VALLEY PLUME	ALTERNATIVE 9 CONTAINMENT OF CENTER OF PLUME AND VALLEY PLUME, TREAT AND OFF-SITE DISCHARGE
IMPLEMENTABILITY									
Ability to Construct and Operate	No construction or operation involved.	Same as Alternative 1.	Common well installation/construction techniques and equipment used for installation of extraction/containment system. Modular treatment system would be easily constructed. Recharge system installation/operation may be difficult due to site topography, land access and geology.	Common well installation/construction techniques and equipment of extraction/containment system. Modular treatment system would be easily constructed. Installation and construction of off-site treated water discharge line will require access to private properties.	More difficult to construct and operate than Alternative 6; large number of wells required to inject treatment materials.	Common construction techniques/ equipment used for installation of extraction/containment system. Modular treatment system would be easily constructed. Recharge system installation may be difficult operation due to site topograpy, land access and geology.	Common construction techniques and equipment used for installation of extraction/containment system. Modular treatment system would be easily constructed. Installation and construction of treatment system and discharge line will require access to private properties.	More difficult to construct and operate than Alternative 7, large number of wells required for injection of treatment materials. Installation and construction of treatment system will require access to private properties.	Same as Alternative 4 and 7.

CRITERION	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 INSTITUTIONAL CONTROLS AND MONITORING	ALTERNATIVE 3 CONTAIN, TREAT AND ON-SITE RECHARGE	ALTERNATIVE 4 CONTAIN, TREAT AND OFF-SITE RECHARGE	ALTERNATIVE 5 IN-SITU TREATMENT OF RESIDUAL/HOT SPOT PLUME	ALTERNATIVE 6 RESIDUAL/HOT SPOT PLUME PUMP AND TREAT, ON-SITE RECHARGE	ALTERNATIVE 7 GROUNDWATER CONTAINMENT OF VALLEY PLUME, ON-SITE TREAT AND OFF-SITE DISCHARGE	ALTERNATIVE 8 IN-SITU TREATMENT OF VALLEY PLUME	ALTERNATIVE 9 CONTAINMENT OF CENTER OF PLUME AND VALLEY PLUME, TREAT AND OFF-SITE DISCHARGE
IMPLEMENTABILITY (continued)									
Ability to Obtain Approvals and Coordinate with Other Agencies	Coordination for 5-year reviews required and would be obtainable.	Same as Alternative 1 Deed restrictions may be difficult to implement and enforce.	Coordination may be required between state and local agencies for pumping and treatment system installation and operation. Groundwater withdrawal permit may be required. Coordination for long-term monitoring and 5-year reviews would be required. Deed restrictions and/or access agreements may be difficult to obtain.	Same as Alternative 3. Permit for stream discharge will be required.	Coordination required between state and local agencies for treatment system installation and operation. Coordination for long-term monitoring and 5-year reviews would be required. Deed restrictions may be difficult to implement.	Same as Alternative 3.	Same as Alternative 3. Permit for stream discharge will be required.	Same as Alternative 5.	Same as Alternatives 4 and 7.
Availability of TSD Services and Capacities	None required.	None required.	Disposal capacity for spent carbon would be required. Used carbon would probably be regenerated and reused.	Same as Alternative 3.	Implementation should generate little RCRA waste.	Same as Alternative 3.	Same as Alternative 3.	Same as Alternative 5.	Same as Alternative 3.

TABLE 6- 1
COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PA

CRITERION	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 INSTITUTIONAL CONTROLS AND MONITORING	ALTERNATIVE 3 CONTAIN, TREAT AND ON-SITE RECHARGE	ALTERNATIVE 4 CONTAIN, TREAT AND OFF-SITE RECHARGE	ALTERNATIVE 5 IN-SITU TREATMENT OF RESIDUAL/HOT SPOT PLUME	ALTERNATIVE 6 RESIDUAL/HOT SPOT PLUME PUMP AND TREAT, ON-SITE RECHARGE	ALTERNATIVE 7 GROUNDWATER CONTAINMENT OF VALLEY PLUME, ON-SITE TREAT AND OFF-SITE DISCHARGE	ALTERNATIVE 8 IN-SITU TREATMENT OF VALLEY PLUME	ALTERNATIVE 9 CONTAINMENT OF CENTER OF PLUME AND VALLEY PLUME, TREAT AND OFF-SITE DISCHARGE
IMPLEMENTABILITY (continued)									
Availability of Equipment, Specialists, and Materials	Personnel and equipment available for implementation of long-term monitoring and 5-year reviews.	Same as Alternative 1.	Ample availability of companies with trained personnel, equipment and materials for installation and operation/ maintenance of groundwater extraction/ containment and treatment systems, long-term monitoring program and 5-year reviews	Same as Alternative 3.	Limited number of equipment and materials vendors; application/ injection methods tend to be patented which limits availability.	Same as Alternative 3.	Same as Alternative 3.	Same as Alternative 5.	Same as Alternative 3.
Availability of Technology	None required.	Sampling and laboratory analyses are widely available technologies.	Groundwater extraction and air stripping/carbon polishing are widely used, conventional technologies available from a variety of companies.	Same as Alternative 3.	Limited availability as new technology for groundwater remediation. Application/ injection methods tend to be patented which limits availability.	Same as Alternative 3.	Same as Alternative 3.	Same as Alternative 5.	Same as Alternative 3.

CRITERION	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 INSTITUTIONAL CONTROLS AND MONITORING	ALTERNATIVE 3 CONTAIN, TREAT AND ON-SITE RECHARGE	ALTERNATIVE 4 CONTAIN, TREAT AND OFF-SITE RECHARGE	ALTERNATIVE 5 IN-SITU TREATMENT OF RESIDUAL PLUME	ALTERNATIVE 6 RESIDUAL PLUME PUMP AND TREAT, ON-SITE RECHARGE	ALTERNATIVE 7 GROUNDWATER CONTAINMENT OF VALLEY PLUME, ON-SITE TREAT AND OFF-SITE DISCHARGE	ALTERNATIVE 8 IN-SITU TREATMENT OF VALLEY PLUME	ALTERNATIVE 9 CONTAINMENT OF CENTER OF PLUME AND VALLEY PLUME, TREAT AND OFF-SITE DISCHARGE
COST									
Capital Cost ($)	$0	$16,074	$6,704,932	$6,339,215	$7,593,660	$3,607,300	$5,366,997	$8,012,805	$10,250,770
First Year Annual O&M Cost ($)	$0	$21,900	$2,258,976	$2,256,429	$21,900	$1,164,872	$223,120	$1,437,500	$2,256,429
Present Worth Cost ($)	$0	$581,148	$14,609,180	$14,211,857	$8,212,634	$8,649,466	$8,627,074	$26,469,716	$20,818,415

standards implementation of this alternative, however, would have no impact on overall protection of off-site users of site-impacted groundwater.

Alternatives 3 and 4 would have a similar degree of overall protection of human health and the environment as in both cases, on-site groundwater with TCE concentrations greater than 1,000 ppb would be extracted and treated on-site to below MCLs, prior to discharge either on-site or off-site (i.e., West Branch Perkiomen Creek). On-site groundwater with TCE concentrations less than 1,000 ppb would not be treated and would continue to flow off-site. Over time there would be a reduction in risk by the implementation of either Alternative 3 or Alternative 4.

The implementation of Alternative 5, in-situ treatment of the residual/hot spot plume would provide some overall protection of human health and the environment to the extent of the effectiveness and permanence of the in-situ treatment process. As treatment would be conducted in-situ, there may be some concerns as to the effect of the treatment process on the environment. No treatment of the dissolved on-site and off-site plumes would occur under this alternative. As the residual/hot spot plume most likely acts as a source of contaminants to the dissolved plume, there would be a reduction in site and off-site risk over a period of time, if the in-situ treatment process permanently decreases TCE and PCE concentrations.

Under Alternative 6, there would be less overall protection of human health and the environment than under Alternatives 3 and 4, as only the residual or hot spot portion of the on-site plume would be extracted for on-site treatment. The dissolved portion of the on-site and off-site plumes would not be addressed, but as for Alternative 5, over an extended period of time there would be a reduction in both site and off-site risk, as the residual plume most likely acts as a "source" of contamination to the dissolved plume. Alternatives 7 and 8 would provide only limited overall protection of human health and the environment as each alternative addresses only a small portion of the TCE plume. Alternative 7 would most likely be more protective than Alternative 8 as the extracted groundwater would be treated to MCLs or below, prior to recharge into adjacent streams.

Alternative 9 would be most protective of human health and the environment as a greater portion of the 1,000 ug/l plume would be treated. Contaminated groundwater with TCE concentrations less than 1,000 ug/l would continue to migrate, however.

6.1.2 Compliance with ARARs and TBCs

Alternatives 1 and 2 when implemented would not comply with federal or state groundwater quality standards.

Alternatives 3, 4, and 9 would comply with applicable federal and state groundwater quality for that portion of the site plume that is contained for on-site treatment (TCE>1000 ug/l). The remaining portion of the plume would be allowed to continue its off-site migration and degrade naturally over time.

Alternatives 5 and 6 address only the residual or hot spot area of the plume (i.e., HN-19, HN-20, and HN-23) where a DNAPL may exist. The dissolved plume located on-site would not be remediated if either Alternative 5 or Alternative 6 is implemented though concentrations may decrease over time. Thus, there may be compliance with ARARs within the groundwater residual zone, but no immediate compliance for the remainder of the dissolved plume that exists on Blackhead Hill or within the Dale Valley area.

Alternative 7 does not address the remediation of site groundwater so there would be no on-site compliance with ARARs. The portion of the valley plume that is within the proposed treatment area should meet applicable ARARs. The same treatment area is addressed by Alternative 8 and the proposed in-situ treatment technology should meet ARARs. Alternatives 7 and 8 may or may not meet location-specific ARARs depending upon the location picked for the proposed treatment systems and its vicinity to historical and/or archeological items (i.e., buildings) of significance.

6.1.3 Reduction Of Toxicity, Mobility, Or Volume Through Treatment

There would be no reduction in the toxicity, mobility, or volume of the site-related hazardous constituents if Alternatives 1 or 2 were implemented. Alternatives 1 and 2 do not provide for any treatment of the contaminated groundwater.

Alternatives 3 and 4 would result in the treatment of approximately 122 million gallons of contaminated groundwater per year of treatment, or about 1,018 pounds of TCE removed annually. The duration of treatment cannot be calculated as the amount of material deposited is not known and/or has not been defined vertically and horizontally. The pre-design investigation for either Alternative 3 or 4 will include the collection of sufficient information to define the length of treatment.

Alternatives 5 and 6 address remediation of the residual or hot spot area of the site plume. As the vertical and horizontal extent of this area has not been completely defined, no estimate of the quantity or duration of treatment can be made. The amount of site-related contaminants treated could be more or less than the amount treated under Alternatives 3 and 4.

Alternatives 7 and 8 would reduce the toxicity and volume of only that portion of the valley plume that comes in contact with the proposed treatment "curtains". There would be no reduction in the volume of contamination at the residual area, except through natural processes like dispersion and degradation.

Alternative 9 would result in the treatment of approximately a million gallons of contaminated water per year of treatment. The duration of treatment would be determined as part of the RD.

6.1.4 Long-Term Effectiveness And Permanence

Alternative 1 would be the least effective and permanent of the nine groundwater alternatives. Alternative 2 would require long-term enforcement of institutional controls to reduce risks to site groundwater, but does not result in a permanent reduction in the levels of groundwater contaminants.

Alternatives 3, 4 and 9 would be effective and permanent over the long term for that portion of the site plume that would be contained and treated.

Alternatives 5 and 6 are also effective and permanent treatment technologies, though Alternative 5 may be more effective in achieving the PRGs. When implemented, however, Alternatives 5 and 6 would only address that portion of the site plume that is considered the residual or hot spot zone. Alternatives 3 and 4 would capture the site plume with TCE concentrations greater than 1,000 ug/l, which includes the residual or hot spot area.

Alternatives 7 and 8 include treatment technologies that should be effective and permanent over the long term, though Alternative 7 would be better at achieving the PRGs. The implementation of either of these alternatives, however, results in the remediation of only a portion of the valley plume and none of the plume located on Blackhead Hill. Alternative 9, if implemented, would result in the long-term and permanent remediation of a greater portion of the site plume.

6.1.5 Short-Term Effectiveness

Alternatives 1 and 2 would provide the least impact to the community, on-site workers, and environment if implemented as no remedial measures would be implemented.

Alternatives 3, 4, 6, and 9 should pose minimal risk to the community or on-site workers when implemented. Alternatives 4 and 9 would result in some short-term disturbance of local traffic in order to place the discharge line beneath Dale Road and across adjacent site owners' properties. Engineering controls could be used during the implementation of either alternative to minimize effects to the environment. Modeling would need to be done to make sure the extraction of water does not effect downgradient supplies.

Alternative 5 should pose minimal risk to the nearby community when implemented, though additional information regarding the site geology and hydrogeology is needed to ensure that the in-situ process would have no affect on downgradient groundwater users or groundwater quality. There may be some short-term effect of increased traffic in the vicinity of the site, through this should occur only on a periodic basis.

The implementation of Alternatives 7 and 8 may pose greater effects on the adjacent community because in order to implement either alternative, access or transfer of ownership of private property would be involved. The treatment system for both alternatives and the groundwater wells would be located off-site from the Crossley Farm. Impacts to remediation workers and the environment should be moderate under Alternative 8.

6.1.6 Implementability

Alternatives 1 and 2 would be the easiest to implement as no construction of remedial measures is involved. Alternative 2 would, however, involve the implementation and enforcement of institutional controls.

Alternative 4 would be slightly easier to implement and operate than Alternative 3 as discharge of the treated groundwater would be to the West Brach Perkiomen Creek and not a series of well fields. Alternatives 6 and 9 would have implementation and operational issues and concerns similar to Alternative 4. Implementation of Alternative 5 is expected to be more difficult than Alternative 6, through the duration of treatment operation may be shorter.

Alternatives 7 and 8 would be the most difficult to implement and operate as each alternative involves the construction and operation of two treatment systems and access to private properties. Alternative 8, in-situ treatment, would be more difficult to implement and operate than Alternative 7.

6.1.7 Cost

There would be no costs associated with the implementation of Alternative 1. The least expensive alternative, with remedial measures, would be Alternative 2. Alternatives 3 and 4 would be more expensive to implement than Alternative 7, capture and treatment of the valley plume, or Alternative 6, capture and treatment of the residual or hot spot plume. Alternative 5, in-situ treatment of the residual plume is more expensive to implement than Alternative 6. Alternative 8 is the most expensive alternative to implement at almost two times the cost of either Alternative 3 or 4.

REFERENCES

REFERENCES

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APPENDICES

A

APPENDIX A

GROUNDWATER CONTAINMENT/EXTRACTION CALCULATIONS

CALCULATION WORKSHEET Order No. 19116 (01-91) PAGE ______ OF ______

CLIENT EPA - Crossley Farm Site	JOB NUMBER
SUBJECT Extraction Network for Dale Valley (Total vertical extent)	
BASED ON	DRAWING NUMBER

BY	CHECKED BY	APPROVED BY	DATE
KCK			

- Estimate the number of extraction wells and total pumping rate required to intercept the groundwater plumes in the Dale valley
- Capture the lateral extent of the plume (>1 ppm), and the entire vertical section of groundwater, regardless of concentrations.
- For each branch:
  - Plume width (1 ppm) ≈ 600 ft (RI report)
  - Assume $K = 5 \times 10^{-3}$ cm/sec (14.2 ft/day); estimate based on Weston (ERT) report → slug tests + aquifer test.
  - Static water level ≈ 25 ft (RI report)
  - Assume base of groundwater flow system ≈ 400 ft (RI rept)
  - Hydraulic head drops ~20 ft over a distance of 2000 ft (RI rept)
  - Assume typical sustainable pumping rate ≈ 20 gpm (drilling observations + well purging data)

For each branch:

$$
\begin{aligned}
Q &= k\,i\,A \\
&= (14.2\ \text{ft/day})(20\ \text{ft}/2000\ \text{ft})(600\ \text{ft} * [400\ \text{ft} - 25\ \text{ft}]) \\
&= 31950\ \text{ft}^3/\text{day} \times 2 = 63900\ \text{ft}^3/\text{day} \\
&\qquad\qquad\qquad\qquad\quad = 331\ \text{gpm}
\end{aligned}
$$

- Assuming 1 well = 20 gpm, each branch requires 17 wells.

For both branches, 34 wells would be required at a total extraction rate of 662 gpm.

AR300221

CALCULATION WORKSHEET Order No. 19116 (01-91) PAGE ____ OF ____

CLIENT EPA - Crossley Farm Site		JOB NUMBER	
SUBJECT EXTRACTION network for southern PLUME - Shallow			
BASED ON		DRAWING NUMBER	
BY KCK	CHECKED BY	APPROVED BY	DATE

- For saprolite/highly fxd bedrock (To depth = 125 feet)
- Estimate number of extraction wells required to intercept the portion of the groundwater plume emanating from the borrow pit that is flowing to the south, and is greater than 1 ppm (1,000 ug/L) in concentration.
  - Assume $K = 5\times10^{-4}$ (1.42 ft/day), estimate based on historical slug tests from older, nearby monitoring wells, (Data from Weston ERT report)
  - Static water level ≈ 25 feet (from RI)
  - Hydraulic head drops about 40 ft over a distance of 250 ft (from RI)
  - Assume most likely sustainable pumping rate ≈ 10 gpm (based on drilling observations + well purging data)
  - Plume width (1 ppm) ≈ 600 ft (from RI)

- Calculate volume of groundwater flowing through the cross-sectional area aligned perpendicular (roughly E-W) through the plume

$$Q = k\, i\, A$$
$$= (1.42\ ft/day)(40\ ft/250\ ft)(600\ ft * [125\ ft - 25\ ft])$$
$$= 13632\ ft^3/day * 2 = 27{,}264\ ft^3/day$$
$$= 142\ gpm$$

- Assuming 1 well ≈ 10 gpm; 14 wells are required.

AR300222

CALCULATION WORKSHEET Order No. 19116 (01-91) PAGE ____ OF ____

CLIENT EPA - Crossley Farm Site		JOB NUMBER	
SUBJECT EXTRACTION network for southern plume - deep			
BASED ON		DRAWING NUMBER	
BY KCK	CHECKED BY	APPROVED BY	DATE

- For Fresher bedrock (125 ft - 400 ft)
- Estimate number of extraction wells required to intercept the portion of the groundwater plume emanating from the borrow pit that is flowing to the south, exists within the fresher, less-fractured bedrock, and is greater than 1 ppm (1,000 ug/L) in concentration
  - Assume $K = 10^{-4}$ cm/sec (0.28 ft/day), estimate based on historical slug tests from older, nearby monitoring wells (Data from Weston ERT report), and on drilling observations
  - Hydraulic head drops 40 feet over a distance of 250 ft (RI report)
  - Plume width (1 ppm) ≈ 600 ft (RI report)
  - Assume base of aquifer ≈ 400 ft (RI rept; drilling observatio
  - Assume most likely sustainable pumping rate ≈ 5 gpm (drilling + well purging observations)

- Calculate volume of groundwater flowing through the cross-sectional area aligned perpendicular (roughly E-W) through the plume

$$Q = kiA$$
$$= (0.28\ \text{ft/day})(40\ \text{ft}/250\ \text{ft})(600\ \text{ft} * [400\ \text{ft} - 125\ \text{ft}])$$
$$= 7{,}392\ \text{ft}^3/\text{day} * 2 = 14784\ \text{ft}^3/\text{day}$$
$$= 77\ \text{gpm}$$

- Assuming 1 well = 5 gpm; 15 wells are required.

AR300223

CALCULATION WORKSHEET Order No. 19116 (01-91) PAGE ____ OF ____

CLIENT EPA - Crossley Farm Site		JOB NUMBER	
SUBJECT Extraction network for western plume - Shallow			
BASED ON		DRAWING NUMBER	
BY KCK	CHECKED BY	APPROVED BY	DATE

- For saprolite/highly fxd bedrock (to depth = 100 feet)
- Estimate the number of extraction wells required to intercept the portion of the groundwater plume emanating from the borrow pit + drum excavation pit, that is flowing to the west within the saprolite + highly fractured bedrock, and is greater than 1 ppm (1,000 ug/L) in concentration.
  - Assume $K = 5 \times 10^{-4}$ cm/sec (1.42 ft/day); estimate based on drilling observations that noted bedrock characteristics are generally similar to boreholes located south of the borrow pit
  - Static water level ≈ 25 feet (from RI)
  - Hydraulic head drops about 40 feet over a distance of 200 feet (from RI)
  - Assume most likely sustainable pumping rate ≈ 10 gpm (based on drilling observations + well purging data)
  - Plume width (1 ppm) ≈ 400 feet (from RI)

- Calculate volume of groundwater flowing through the cross-sectional area aligned perpendicular (roughly N-S) through the plume.

$$
\begin{aligned}
Q &= k\,i\,A \\
&= (1.42\ \text{ft/day})(40\ \text{ft}/200\ \text{ft})(400\ \text{ft} * [100\ \text{ft} - 25\ \text{ft}]) \\
&= 8520\ \text{ft}^3/\text{day} * 2 = 17{,}040\ \text{ft}^3/\text{day} \\
&\qquad\qquad = 89\ \text{gpm}
\end{aligned}
$$

- Assuming 1 well ≈ 10 gpm; 9 wells are required

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CLIENT EPA - Crossley Farm Site		JOB NUMBER	
SUBJECT Extraction network for western plume - Deep			
BASED ON		DRAWING NUMBER	
BY KCK	CHECKED BY	APPROVED BY	DATE

- For fresher bedrock (75 - 300 ft)
- Estimate number of extraction wells required to intercept the portion of the groundwater plume emanating from the borrow pit and the drum excavation pit, that is flowing to the west within the fresher, less-fractured bedrock, and is greater than 1 ppm (1,000 ug/L) in concentration.
  - Assume $K = 5 \times 10^{-5}$ cm/sec (0.056 ft/day), based on drilling observations and well purging data.
  - Hydraulic head drops about 50 feet over a distance of 150 feet (RI report)
  - Assume most likely sustainable pumping rate ≈ 3 gpm (drilling + well purging observations)
  - Plume width (1 ppm) ≈ 200 ft (RI report)

- Calculate volume of groundwater flowing through the cross-sectional area aligned perpendicular (roughly N-S) through the plume.

$$
\begin{aligned}
Q &= k\,i\,A \\
&= (0.056\ \text{ft/day})(50\ \text{ft}/150\ \text{ft})(200\ \text{ft} * [300\ \text{ft} - 75\ \text{ft}]) \\
&= 840\ \text{ft}^3/\text{day} \times 2 = 1680\ \text{ft}^3/\text{day} \\
&= 9\ \text{gpm}
\end{aligned}
$$

- Assuming 1 well = 3 gpm; 3 wells are required

AR300225

CALCULATION WORKSHEET Order No. 19116 (01-91)

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CLIENT EPA- Crossley Farm Site	JOB NUMBER
SUBJECT Extraction Network for Dale Valley (>1 ppm only)	
BASED ON	DRAWING NUMBER

BY	CHECKED BY	APPROVED BY	DATE
KCK			

- Estimate the number of extraction wells and total pumping rate required to intercept the groundwater plumes in the Dale valley.
- Capture the lateral extent of the plume (>1 ppm), and only the vertical section of the plume contaminated to concentrations >1 ppm.
  - Assume this portion of the plume extends from a subsurface depth of 150 to 400 feet (RI rept)

For each branch:
- Plume width (1 ppm) ≈ 600 ft (RI report)
- Assume $K = 5 \times 10^{-3}$ cm/sec (14.2 ft/day); estimate based on Weston (ERT) report → slug tests & aquifer test
- Static water level ≈ 25 ft (RI report)
- Assume base of groundwater flow system ≈ 400 ft (RI rept)
- Hydraulic head drops ~ 20 ft over a distance of 2000 ft (RI rept)
- Assume typical sustainable pumping rate ≈ 20 gpm (drilling observations & well purging data)

For each branch:

$$
\begin{aligned}
Q &= kiA \\
&= (14.2\ \text{ft/day})(20\ \text{ft}/2000\ \text{ft})(600\ \text{ft}\,[400\ \text{ft} - 150\ \text{ft}]) \\
&= 21300\ \text{ft}^3/\text{day} \times 2 = 42600\ \text{ft}^3/\text{day} \\
&\qquad\qquad\qquad\qquad\quad = 220\ \text{gpm}
\end{aligned}
$$

- Assuming 1 well = 20 gpm, each branch requires 11 wells.

For both branches, 22 wells would be required at a total extraction rate of 440 gpm.

CALCULATION WORKSHEET Order No. 19116 (01-91)

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CLIENT EPA - Crossley Farm Site	JOB NUMBER
SUBJECT Conceptual Limited Withdrawal at Residual Source Area	
BASED ON	DRAWING NUMBER

BY	CHECKED BY	APPROVED BY	DATE
KCK			

- Limited groundwater extraction network designed to extract groundwater from the residual source area associated with borrow pit.
- Define residual source area as extending from the borrow pit downgradient to the HN-19, 20, 23 area, or the groundwater contaminated to concentrations exceeding 10^5 VOCs (RI rept)
- Assume residual source is present through the entire vertical extent of the groundwater flow system, or a depth of approximately 400 ft (RI rept)

- Assume 8 wells to be installed in vicinity of MWs HN-19, 20, 23
  - 4 wells to 125 ft (appx saprolite/fresh bedrock interface), pumping at ~ 5 gpm each
  - 4 wells to 400 ft, pumping at ~ 2.5 gpm each

- Assume 2 wells installed in immediate vicinity of borrow pit.
  - 1 well to depth of 125 ft @ 5 gpm
  - 1 well to depth of 400 ft @ 5 gpm

B

APPENDIX B

CONCEPTUAL TREATMENT DESIGN CALCULATIONS

1.0 DESIGN ASSUMPTIONS

The following design assumptions are made:

- Assuming a porosity of 35 percent, the approximate volume of the center plume is 547 million gallons with TCE in excess of 1,000 µg/L.
- Groundwater contamination extends to a depth of approximately 400 ft below ground surface (bgs)..

2.0 TREATMENT SCHEME

Alternative 3 would consist of a "pump-and-treat" system extracting and treating groundwater from the southern and western lobes of the center plume and featuring the following elements:

- Groundwater extraction wells and pumps
- Equalization
- Filtration
- Air stripping with offgas treatment
- Liquid-Phase Granular Activated Carbon (GAC) Adsorption

3.0 GROUNDWATER EXTRACTION WELLS AND PUMPS

3.1 Extraction Rates

As per attached calculations and as shown on Figure 4-3, the design of groundwater extraction wells may be summarized as follows:

Well Number	Location	Depth (ft)	Pumping Rate (gpm per well)
EW-1 to EW-14	Southern Lobe	125	7.552
EW-15 to EW-29	Southern Lobe	400	7.552
EW-30 to EW-38	Western Lobe	125	8.167
EW-39 to EW-41	Western Lobe	400	8.167
Total			317

3.2 Extraction Pumps Design

Multi-stage submersible centrifugal pumps would be installed in the above wells as follows:

Well Number	Pump Design		
	Flow Rate (gpm)	Total Discharge Head (ft)	Motor Size (HP)
EW-1 to EW-14	10	200	1.5
EW-15 to EW-29	10	500	3.0
EW-30 to EW-38	10	200	1.5
EW-39 to EW-41	10	500	3.0
Total	410		

Accordingly, the pump-and-treat system is designed for a hydraulic flow of 400 gpm but contaminant quantities and chemical usage will be based upon a design operating flow of 317 gpm.

3.3 Extracted Groundwater Quality

The average VOC concentrations in the groundwater extracted from the southern lobe of the center plume is assumed to be the mathematical average of the concentrations detected in wells HN19I, HN20S, HN20I, and HN23I, as follows:

Well	TCE (μg/L)	PCE(μg/L)
HN19I	41,000	1,700
HN20S	7,500	380
HN20I	24,000	1,100
HN23I	190,000	6,000
Average southern edge	65,600	2,300

The average VOC concentrations in the groundwater extracted from the western lobe of the center plume is assumed to be the mathematical average of the concentrations detected in wells HN10I1, HN10I2, and MW1.10B, as follows:

Well	TCE (μg/L)	PCE(μg/L)
HN10I1	8,500	
HN10I2	4,200	
MW1.10B	4,300	110
Average western edge	5,700	100

The average VOC concentrations of the equalized extracted groundwater is computed as follows (rounded to the next 100 μg/L):

TCE: [(65,600 μg/L x 219 gpm) + (5,700 μg/L x 98 gpm)] ÷ 317 gpm = 47,100 μg/L

PCE: [(2,300 μg/L x 219 gpm) + (100 μg/L x 98 gpm)] ÷ 317 gpm = 1,600 μg/L

4.0 EQUALIZATION

Provide equalization tank to blend groundwater from various extraction wells. Equalization tank would be equipped with a mixer and would feature a closed-top design to control VOCs emission. Equalization tank would be vented to the inlet of the air stripper blower. Equalization tank would be sized to provide 30 minutes detention under design flow conditions.

Equalization Tank Volume: 400 gpm x 30 minutes = 12,000 gallons

→ Call for a 12-foot diameter 15 feet high equalization tank with a working capacity of 12,000 gallons. Tank to be of cylindrical vertical configuration and manufactured of fiberglass or painted carbon steel. Tank to be of closed-top design with vent.

Mixer size @ 0.5 HP/1,000 gal: 12,000 gallons x 0.5 HP ÷ 1,000 gallons = 6, say 7.5 HP

→ Call for a top-mounted 7.5 HP low-speed turbine-type mixer.

Pumps would be provided to transfer groundwater from equalization tank to downstream treatment processes. Two transfer pumps should be provided, including an installed spare. Pump operation (start/stop) would be controlled by the liquid level in the equalization tank.

→ Call for two (one installed spare) horizontal-centrifugal 400 gpm equalized groundwater transfer pumps (75 ft design TDH, 15 HP motor).

5.0 FILTRATION

Use bag type filter unit to avoid liquid residual stream from backwashing.

Size bag filter unit for replacement of filter bag element no more frequently than once a week.

Assuming approximately 5 mg/L TSS in untreated groundwater and 90% removal, TSS accumulation in the filter within a week would be:

317 gpm x 1,440 min/day x 7 days/week x 8.34 lbs/gal x [(5 – 0.5) mg/l] x 10^{-6} = 120 lbs dry TSS /week

Assuming a typical solids capture capacity of approximately 1.0 lbs dry TSS per square foot of bag filter element, required surface of bag element is:

120 lbs ÷ 1.0 lbs/ft^2 = 120, say 125 ft^2

→ Call two (one standby) multi-bag pressurized filter unit with a total filter area of 125 ft^2

6.0 AIR STRIPPING WITH OFFGAS TREATMENT

Filtered groundwater would be treated in a packed tower air stripper for the removal of chlorinated VOCs. According to the attached calculations, the design of this air stripper may be summarized as follows:

Groundwater Flow:	317 gpm
Design Influent VOC Concentrations:	47,100 µg/L TCE, 1,600 µg/L PCE
Design Effluent VOC Concentrations:	3.7 µg/L TCE, 0.1 µg/L PCE
Stripper Column Diameter:	6.0 feet
Packing Depth:	30 feet
Packing Type:	Loose 2-inch Jaeger Tripack
Air-to-Water Ratio:	90:1
Stripper Blower Flow:	3,810 cfm
Stripper Blower Discharge Pressure:	0.35 psi
Stripper Blower Motor Size:	10 HP

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→ Call for one 6 ft diameter x 46 ft high packed-column type air stripper with 3,800 cfm air blower (Carbonair Model OS-500 or equivalent)..

Treated groundwater would be pumped from the sump of the air stripper to the liquid-phase granular activated carbon (GAC) adsorption unit by one of two horizontal centrifugal pumps (one installed spare). Pump operation (start/stop) would be controlled by the liquid level in the air stripper sump.

→ Call for two (one installed spare) horizontal-centrifugal 400 gpm treated groundwater discharge pumps (100 ft design TDH, 20 HP motor).

Air stripper offgas would be treated in a vapor-phase GAC system to remove VOCs. The humidity of the offgas would be reduced from 100% to 50% by an electric air dryer to optimize the adsorption process.

Water in air @ 100% humidity – Water in air @ 50% humidity = (0.014 – 0.007) = 0.007 lbs H_2O/ lb air

Weight of water to be removed: 3,800 cfm air x 0.075 lbs/ft^3 air x 0.007 lbs H_2O/lb air = 2.0 lbs H_2O/min

Power needed to remove water: 2.0 lbs H_2O/min x 1,100 BTU/lb H_2O x 0.01757 kW/BTU/min = 38.6 kW

→ Call for a 40 kW electrical air dryer.

The main chlorinated VOC in the vapor extraction system offgas would be TCE and it is assumed that approximately 10 pounds of GAC would be consumed for each pound of VOC removed.

Total weight of chlorinated VOCs in offgas over operating life of the system:

547,000,000 gallons x 8.34 lbs/gal x (48.7 – 0.0038) mg/L VOCs x 10^{-6} = 222,150 lbs VOCs

Total GAC consumption over operating life of the system:

222,150 lbs VOCs x 10 lbs GAC/lb VOC = 2,221,500 lbs GAC

Initial weight of VOCs in offgas:

317 gpm x 1,440 min/day x 8.34 lbs/gal x (48.7 – 0.0038) mg/L VOCs x 10^{-6} = 185 lbs VOCs/day

Initial GAC consumption:

185 lbs VOCs/day x 10 lbs GAC/lb VOC = 1,850 lbs GAC/day or 675,250 lbs GAC/year

→ Call for a vapor-phase GAC adsorption system consisting of two (2) adsorption unit operating in series, each holding 13,600 lbs GAC (Carbonair GPC 120 or equivalent). System to be designed such that either unit can be placed in the lead or lag position.

Estimated replacement frequency of lead GAC adsorption unit over the operating life of the system:

(2,221,500 lbs total GAC use÷13,600 lbs GAC in lead unit) – 1 (initial charge) = 162.3, say 162 replacements

Initial frequency of replacement:

13,600 lbs GAC in lead unit ÷ 1,850 lbs/day initial GAC use = 7.3 days, or 50 times a year

For costing purposes, it will be assumed that the lead GAC unit would be replaced 162 times over 30 years, in accordance to the following schedule:

Years	Replacements per Year
1	50
2	35
3	15
4	8
5-10	4
11-20	2
21-30	1

7.0 LIQUID-PHASE GRANULAR ACTIVATED CARBON ADSORPTION

Air stripped groundwater would be treated in a liquid-phase GAC adsorption system to remove residual *chlorinated VOC prior to discharge.*

The liquid-phase GAC adsorption system would be designed to feature two units operating in series with each unit sized to provide an empty bed contact time (EBCT) of 2 minutes.

Required GAC capacity per unit:

400 gpm x 2 minutes = 800 ft^3 GAC or, @ approximately 30 lbs/ft^3, 24,000 lbs GAC

However, largest commercially available liquid-phase GAC adsorption unit holds only 20,000 lbs, which should be sufficient for polishing.

→ *Call for a liquid-phase GAC adsorption system consisting of two (2) adsorption units operating in series,* each holding 20,000 lbs GAC (Carbonair PC-78 or equivalent). Adsorption units to be designed to allow for periodic backwash.

It is assumed that approximately 15 pounds of GAC will be consumed per pound of residual VOC removed.

Estimated quantity of residual chlorinated VOCs in air stripper effluent:

317 gpm x 1,440 min/day x 8.34 lbs/gal x 0.0038 mg/L VOCs x 10^{-6} = 0.0145 lbs VOCs/day

Estimated GAC usage:

0.0145 lbs VOC/day x 15 lbs GAC/lb VOC removed = 0.217 lbs GAC/day or 79.4 lbs/year

Estimated replacement frequency of lead GAC adsorption unit over the operating life of the system:

[(79.4 lbs/year GAC use x 30 years operating time) ÷ 20,000 lbs GAC in lead unit] – 1 (initial charge) = -0.88

No replacement needed

1.0 DESIGN ASSUMPTIONS

The following design assumptions are made:

- Based on an assumed porosity of 35 percent, the approximate volume of the residual plume is 113 million gallons with TCE in excess of 100,000 µg/L.
- Groundwater contamination extends to a depth of approximately 400 ft below ground surface (bgs)..
- Average chlorinated VOCs concentrations in the residual plume are those detected at monitoring well HN23I, i.e., 190,000 µg/L TCE and 6,000 µg/L PCE.

2.0 TREATMENT SCHEME

Alternative 6 would consist of a "pump-and-treat" system extracting and treating groundwater from the residual plume and featuring the following elements:

- Groundwater extraction wells and pumps
- Equalization
- Filtration
- Air stripping with offgas treatment
- Liquid-Phase Granular Activated Carbon Adsorption

3.0 GROUNDWATER EXTRACTION WELLS AND PUMPS

As per attached calculations and as shown on Figure 3-7, the design of groundwater extraction wells may be *summarized as follows:*

Well Number	Location	Depth (ft)	Pumping Rate (gpm per well)
EW-1 to EW-4	Along gravel road	125	3.75
EW-5 to EW-8	Along gravel road	400	3.75
EW-9	Borrow Pit	125	5
EW-10	Borrow Pit	400	5
Total			40

Multi-stage submersible centrifugal pumps would be installed in the above wells as follows:

Well Number	Pump Design		
	Flow Rate (gpm)	**Total Discharge Head** (ft)	**Motor Size** (HP)
EW-1 to EW-4	4	200	0.5
EW-5 to EW-8	4	500	1.0
EW-9	5	200	0.5
EW-10	5	500	1.5
Total	42		

Accordingly, the pump-and-treat system is designed for a hydraulic flow of 50 gpm but contaminant quantities and chemical usage will be based upon a design operating flow of 40 gpm.

4.0 EQUALIZATION

Provide equalization tank to blend groundwater from various extraction wells. Equalization tank would be equipped with a mixer and would feature a closed-top design to control VOCs emission. Equalization tank would be vented to the inlet of the air stripper blower. Equalization tank would be sized to provide 30 minutes detention under design flow conditions.

Equalization Tank Volume: 50 gpm x 30 minutes = 1,500 gallons

→ Call for a 6-foot diameter 9 feet high equalization tank with a working capacity of 1,500 gallons. Tank to be of cylindrical vertical configuration and manufactured of fiberglass or painted carbon steel. Tank to be of closed-top design with vent.

Mixer size @ 0.5 HP/1,000 gal: 1,500 gallons x 0.5 HP ÷ 1,000 gallons = 0.75 HP

→ Call for a top-mounted 0.75 HP low-speed turbine-type mixer.

Pumps would be provided to transfer groundwater from equalization tank to downstream treatment processes. Two transfer pumps should be provided, including an installed spare. Pump operation (start/stop) would be controlled by the liquid level in the equalization tank.

→ Call for two (one installed spare) horizontal-centrifugal 50 gpm equalized groundwater transfer pumps (75 ft design TDH , 2 HP motor).

5.0 FILTRATION

Use bag type filter unit to avoid liquid residual stream from backwashing.

Size bag filter unit for replacement of filter bag element no more frequently than once a week.

Assuming approximately 5 mg/L TSS in untreated groundwater and 90% removal, TSS accumulation in the filter within a week would be:

40 gpm x 1,440 min/day x 7 days/week x 8.34 lbs/gal x [(5 – 0.5) mg/l] x 10^{-6} = 15.1 lbs dry TSS /week

Assuming a typical solids capture capacity of approximately 1.0 lbs dry TSS per square foot of bag filter element, required surface of bag element is:

15.1 lbs ÷ 1.0 lbs/ft^2 = 15.1, say 20 ft^2

→ Call two (one standby) multi-bag pressurized filter unit with a total filter area of 20 ft^2

6.0 AIR STRIPPING WITH OFFGAS TREATMENT

Filtered groundwater would be treated in a packed tower air stripper for the removal of chlorinated VOCs. According to the attached calculation the design of this air stripper may be summarized as follows:

Groundwater Flow:	40 gpm
Design Influent VOC Concentrations:	190,000 µg/L TCE, 6,000 µg/L PCE
Design Effluent VOC Concentrations:	3.1 µg/L TCE, 0.1 µg/L PCE

Stripper Column Diameter:	3.0 feet
Packing Depth:	30 feet
Packing Type:	Loose 2-inch Jaeger Tripack
Air-to-Water Ratio:	100:1
Stripper Blower Flow:	534 cfm
Stripper Blower Discharge Pressure:	1.5 psi
Stripper Blower Motor Size:	7.5 HP

→ Call for one 3 ft diameter x 45 ft high packed-column type air stripper with 550 cfm air blower (Carbonair Model OS-300 or equivalent)..

Treated groundwater would be pumped from the sump of the air stripper to the liquid-phase granular activated carbon (GAC) adsorption unit by one of two horizontal centrifugal pumps (one installed spare). Pump operation (start/stop) would be controlled by the liquid level in the air stripper sump.

→ Call for two (one installed spare) horizontal-centrifugal 50 gpm treated groundwater discharge pumps (100 ft design TDH, 2.5 HP motor).

Air stripper offgas would be treated in a vapor-phase GAC system to remove VOCs. The humidity of the offgas would be reduced from 100% to 50% by an electric air dryer to optimize the adsorption process.

Water in air @ 100% humidity – Water in air @ 50% humidity = (0.014 – 0.007) = 0.007 lbs H_2O/ lb air

Weight of water to be removed: 550 cfm air x 0.075 lbs/ft^3 air x 0.007 lbs H_2O/lb air = 0.29 lbs H_2O/min

Power needed to remove water: 0.29 lbs H_2O/min x 1,100 BTU/lb H_2O x 0.01757 kW/BTU/min = 5.6 kW

→ Call for a 7.5 kW electrical air dryer.

The main chlorinated VOC in the vapor extraction system offgas would be TCE and it is assumed that approximately 10 pounds of GAC would be consumed for each pound of VOC removed.

Total weight of chlorinated VOCs in offgas over operating life of the system:

113,000,000 gallons x 8.34 lbs/gal x (196 – 0.0031) mg/L VOCs x 10^{-6} = 184,700 lbs VOCs

Total GAC consumption over operating life of the system:

184,700 lbs VOCs x 10 lbs GAC/lb VOC = 1,847,000 lbs GAC

Initial weight of VOCs in offgas:

40 gpm x 1,440 min/day x 8.34 lbs/gal x (196 – 0.0031) mg/L VOCs x 10^{-6} = 94 lbs VOCs/day

Initial GAC consumption:

94 lbs VOCs/day x 10 lbs GAC/lb VOC = 940 lbs GAC/day or 343,100 lbs GAC/year

→ Call for a vapor-phase GAC adsorption system consisting of two (2) adsorption unit operating in series and each holding 13,600 lbs GAC (Carbonair GPC 120 or equivalent). System to be designed such that either unit can be placed in the lead or lag position.

Estimated replacement frequency of lead GAC adsorption unit over the operating life of the system:

(1,847,000 lbs total GAC use ÷ 13,600 lbs GAC in lead unit) – 1 (initial charge) = 134.8, say 135 replacements

Initial frequency of replacement:

13,600 lbs GAC in lead unit ÷ 940 lbs/day initial GAC use = 14.4 days, say once every two weeks or 26 times a year

For costing purposes, it will be assumed that the lead GAC unit would be replaced 135 times over 30 years, in accordance to the following schedule:

Years	Replacements per Year
1	26
2-3	12
4-8	7
9-15	3
16-30	2

7.0 LIQUID-PHASE GRANULAR ACTIVATED CARBON ADSORPTION

Air stripped groundwater would be treated in a liquid-phase GAC adsorption system to remove residual chlorinated VOC prior to discharge.

The liquid-phase GAC adsorption system would be designed to feature two units operating in series with each unit sized to provide an empty bed contact time (EBCT) of 2 minutes.

Required GAC capacity per unit:

50 gpm x 2 minutes = 100 ft^3 GAC or, @ approximately 30 lbs/ft^3, 3,000 lbs GAC

→ Call for a liquid-phase GAC adsorption system consisting of two (2) adsorption units operating in series and each holding 5,000 lbs GAC (Carbonair PC-28 or equivalent). Each unit to be designed to allow for periodic backwash.

It is assumed that approximately 15 pounds of GAC will be consumed per pound of residual VOC removed.

Estimated quantity of residual chlorinated VOCs in air stripper effluent:

40 gpm x 1,440 min/day x 8.34 lbs/gal x 0.0031 mg/L VOCs x 10^{-6} = 0.0015 lbs VOCs/day

Estimated GAC usage:

0.0015 lbs VOC/day x 15 lbs GAC/lb VOC removed = 0.0225 lbs GAC/day or 8 lbs/year

Estimated replacement frequency of lead GAC adsorption unit over the operating life of the system:

[(8 lbs/year GAC use x 30 years operating time) ÷ 5,000 lbs GAC in lead unit] – 1 (initial charge) = -0.95

No replacement needed.

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SUBJECT: Crossley Farm Site FS Alternative 7: Valley Plumes Pump-and-Treat		CHECKED BY:	DATE: 01/26/01

1.0 DESIGN ASSUMPTIONS

The following design assumptions are made:

- Based on an assumed porosity of 35 percent, the approximate volume of each of the two Valley Plumes (East & West) is 315 million gallons.
- Groundwater contamination extends to a depth of approximately 400 ft below ground surface (bgs)..
- Average TCE concentration in the Valley Plumes is the average of TCE concentrations detected at monitoring wells HN/MW-06D (1,200 µg/L) and HN/MW-07D (210 µg/L), i.e., 705 µg/L.

2.0 TREATMENT SCHEME

Alternative 7 would consist of two "pump-and-treat" systems, each one extracting and treating groundwater from the one of the Valley Plumes and featuring the following elements:

- Groundwater extraction wells and pumps
- Equalization
- Liquid-Phase Granular Activated Carbon (GAC) Adsorption

3.0 GROUNDWATER EXTRACTION WELLS AND PUMPS

As per attached calculations and as shown on Figure 3-, the design of groundwater extraction wells for the East and West Valley Plumes may be summarized as follows:

Well Number	Location	Depth (ft bgs)	Pumping Rate (gpm per well)
EW-1 to EW-11	East Valley Plume	400	20
EW-12 to EW-22	West Valley Plume	400	20

Multi-stage submersible centrifugal pumps would be installed in the above wells as follows:

Well Number	Pump Design		
	Flow Rate (gpm)	Total Discharge Head (ft H_2O)	Motor Size (HP)
EW-1 to EW-11	20/pump	500	5
Subtotal East Valley Plume	220		
EW-17 to EW-32	20/pump	500	5
Subtotal West Valley Plume	220		

Accordingly, each of the pump-and-treat systems is designed for a hydraulic flow of 250 gpm but contaminant quantities and chemical usage are based upon a design operating flow of 220 gpm.

4.0 EQUALIZATION

Provide equalization tank to blend groundwater from various extraction wells. Equalization tank would be equipped with a mixer and would feature a closed-top design to control VOCs emission. Equalization tank would be vented to the inlet of the air stripper blower. Equalization tank would be sized to provide 30 minutes detention under design flow conditions.

Equalization Tank Volume: 250 gpm x 15 minutes = 7,500 gallons

→ Call for a 10-foot diameter 14 feet high equalization tank with a working capacity of 7,500 gallons. Tank to be of cylindrical vertical configuration and manufactured of painted carbon steel. Tank to be of closed-top design with vent.

Mixer size @ 0.5 HP/1,000 gal: 7,500 gallons x 0.5 HP ÷ 1,000 gallons = 3.75, say 5 HP

→ Call for a top-mounted 5 HP low-speed turbine-type mixer.

Pumps would be provided to transfer groundwater from the equalization tank to downstream treatment processes. Two transfer pumps should be provided, including an installed spare. Pump operation (start/stop) would be controlled by the liquid level in the equalization tank.

→ Call for two (one installed spare) horizontal-centrifugal 250 gpm equalized groundwater transfer pumps (75 ft design TDH , 10 HP motor).

5.0 LIQUID-PHASE GRANULAR ACTIVATED CARBON ADSORPTION

Equalized groundwater would be treated in a liquid-phase GAC adsorption system to remove TCE prior to discharge.

The liquid-phase GAC adsorption system would feature two absorption units operating in series with each unit providing an empty bed contact time (EBCT) of 10 minutes.

Required GAC capacity per adsorption unit:

(250 gpm x 10 minutes) ÷ 7.485 gal/ ft^3 = 334 ft^3 GAC or, @ approximately 30 lbs/ft^3, 10,020 lbs GAC

→ Call for a liquid-phase GAC adsorption system consisting of two (2) adsorption units operating in series, each holding 10,000 lbs GAC (Carbonair PC-50 or equivalent). Adsorption units to be designed to allow for periodic backwash.

Assume that approximately 15 pounds of GAC will be consumed per pound of TCE removed.

Total weight of TCE in each Valley Plume:

315,000,000 gallons x 8.34 lbs/gal x 0.705 mg/L TCE x 10^{-6} = 1,852 lbs TCE

Total GAC consumption over operating life of the system:

1,852 lbs TCE x 15 lbs GAC/lb TCE = 27,781 lbs GAC

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Estimated number of replacements of lead GAC adsorption units over the operating life of the system:

[27,781 lbs total GAC use ÷ 10,000 lbs GAC in lead unit] – 1 (initial charge) = 1.78

Two replacements needed.

Initial GAC usage:

(250 gpm x 1,440 min/day x 8.34 lbs/gal x 0.705 mg/L TCE x 10-6) x 15 lbs GAC/lb TCE = 31.7 lbs GAC/day

Call for one replacement of lead GAC unit during Year 2 and one replacement during Year 10.

MANTECH ENVIRONMENTAL CORPORATION
A ManTech International Subsidiary

August 25, 2000

Tetra Tech NUS, Inc.
600 Clark Avenue
Suite 3
King of Prussia, PA 19406-1433

RE: CleanOX® Process Engineering Cost Estimate
RAC 3 Program, EPA Contract No. 68-S8-3003
Crossley Farm Superfund Site, Work Assignment 009-RICO-03S2
ManTech Proposal No. C-00-422

Dear

ManTech Environmental Corporation (ManTech) is pleased to provide this engineering cost estimate to Tetra Tech NUS, Inc. (TtNUS) for applying the CleanOX® Process at the Crossley Farm Superfund site located in Berks County, Pennsylvania. This preliminary estimate includes cost estimates for conducting bench testing, preliminary planning, a pilot-scale field application, post-treatment reporting, and an estimate of full-scale costs.

The CleanOX® Process is a patented *in-situ* technology that involves the staged application of Fenton Reaction chemistry to create oxidation-reduction reactions leading to the degradation of organic constituents present in groundwater and saturated soil. The CleanOX® Process appears to be a potentially applicable technology to address the contamination at the Crossley Farm Superfund site for several reasons.

- Applicable Technology. The CleanOX® Process is a recognized, innovative remediation technology proven effective in the cleanup of organic compounds that have been detected at the Crossley Farm Superfund site.

- No Generated Wastes. The process uses a proprietary formulation of reagents that are applied through application wells directly into the area of concern. The reagents treat contaminated groundwater and saturated soil *in-situ*, producing no waste streams that require permitting, treatment, or disposal.

- Short Time. Reductions in organic contaminant concentrations are produced in a matter of days to weeks as compared to the many years required for other remediation technologies. The CleanOX® Process is commonly applied to application wells located inside site buildings and is not known to impede other work at active facilities.

MANAGEMENT TECHNOLOGY 14290 Sullyfield Circle, Suite 100, Chantilly, Virginia 20151 Telephone 703.378.1030 Facsimile 703.378.3396

- Low Costs. Because the CleanOX® Process remediates organic contaminants within a relatively short period of time, it eliminates the costly long-term operation and maintenance (O&M) that is associated with conventional remediation technologies.

Another important advantage of the CleanOX® Process is that it can be bench tested to determine the applicability of the technology for treatment of a specific contaminant(s) at the property in question. A bench test on groundwater and saturated soil samples from the property is performed to determine reactivity of the media to be treated and the appropriate dosage rate for reducing contaminant concentrations. These bench test results, in combination with site geologic and hydrogeologic characteristics, provide the basis for estimating the CleanOX® reagent dosage rate during the field application.

This sequence of testing allows for opportunities to determine the applicability of the technology before the budget of a full-scale program is committed. The treatment approach can also be customized to address "hot spots" or portions of the contamination that have not been adequately addressed by selectively adding new application wells and/or providing additional round(s) of treatment, as required.

ManTech understands from our review of your August 2, 2000, letter and attached information, that *in-situ* chemical oxidation is being evaluated for use at the site to address chlorinated volatile organic compound (VOC) contamination in the saturated zone soil and groundwater at the site. Specifically, TtNUS is interested in addressing two areas at the site: (1) area of approximately 200 feet by 600 feet (nearly three acres) situated around sampling points HN19, HN20, and HN23 over an interval from 20 feet to 400 feet below grade; and (2) establishing two 'treatment curtains' downgradient of the source area. Each treatment curtain would consist of an 800 feet long treatment area positioned perpendicular to groundwater flow. The treatment curtain interval would be from 150 feet to 400 feet below grade. ManTech has made certain assumptions in preparing this engineering estimate and we can review additional site information in order to prepare a more accurate cost proposal.

Bench and Pilot Testing

The general steps involved in applying the CleanOX® Process include conducting a bench test, preparing a Work Plan for a pilot-scale application, locating and installing application wells, conducting the pilot-scale application, and preparing a technical report. The bench test with report can be completed on site groundwater samples (one from each proposed treatment area) for $3,500, excluding sample collection and laboratory analytical costs. ManTech will develop a Work Plan that includes review of more detailed site information, a discussion of the bench test results and their significance, and the scope of work for conducting the pilot-scale application. Cost to prepare a Work Plan is $7,500. The cost for a technical report at the conclusion of the project is estimated at $7,500.

ManTech estimates that the pilot-scale application would require four, 2-inch diameter stainless steel application wells to be installed around existing wells in each of the two areas (eight wells total). Two of the wells would be installed to a total depth of approximately 80 feet below grade to effect reductions to the upper portion of the treatment area (60 to 80 feet below grade). The remaining two wells would be installed to a total depth of approximately 300 feet below grade to effect reductions to the lower portion of the treatment area. ManTech recommends using existing site monitoring wells for monitoring site groundwater before, during, and after the application to verify the effectiveness of the CleanOX® treatment.

ManTech will mobilize a field crew, equipment, and materials to the Crossley Farm Superfund site, and apply two cycles of the CleanOX® Process to the eight pilot test application wells. Estimated cost to conduct the two-cycle pilot test application in both areas, excluding well installation and post-treatment sample collection and analysis costs, is approximately $125,000. Therefore, total project cost to complete the above scope of work including the bench test and final report is estimated at $143,500.

ManTech estimates that the field application program can be completed within three to five months, depending on the regulatory approval process involved and laboratory analytical turnaround time.

Full-Scale

While the full-scale technical approach and cost estimate is best prepared based on pilot study data, ManTech has prepared a conceptual approach to using the CleanOX® Process to address larger portions of the site. In the first treatment area, around sampling points HN19, HN20, and HN 23, ManTech estimates that approximately 100 to 150 application wells would be required. Application wells would need to be installed so that the interval from 20 feet to 400 feet below grade could be treated. Treatment costs, exclusive of well installation and sampling and analytical costs, are estimated to range from $1.25 to $1.875 million. In the second treatment area, the two treatment curtains, ManTech estimates that 50 wells would be needed in each area, or 100 wells total. Assuming that each treatment curtain has reagents applied quarterly, ManTech estimates annual treatment costs to range from $1.0 to $1.25 million, exclusive of well installation and sampling and analytical costs.

I hope this information is useful in evaluating remediation options at the Crossley Farm Superfund site. Please contact me at 703-814-8366 or at ron.adams@mantech.com if you need additional information.

Sincerely,

Ronald F. Adams, P.E.
Executive Director

C

APPENDIX C

COSTING TABLES AND SPREADSHEETS

CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater
Alternative 2: Institutional Controls and Groundwater Monitoring
Capital Cost

Item	Quantity	Unit	*Unit Cost* Subcontract	Material	Labor	Equipment	Total Cost Subcontract	Material	Labor	Equipment	Total Direct Cost
1 PROJECT DOCUMENTS/INSTITUTIONAL CONTROLS											
1.1 Prepare Deed Restrictions	200	hr			$40.00		$0	$0	$8,000	$0	$8,000
Subtotal							$0	$0	$8,000	$0	$8,000
Local Area Adjustments							100.0%	100.0%	124.8%	124.8%	
Subtotal							$0	$0	$9,984	$0	$9,984
Overhead on Labor Cost @ 30%									$2,995		$2,995
G & A on Labor Cost @ 10%									$998		$998
G & A on Material Cost @ 10%								$0			$0
G & A on Subcontract Cost @ 10%							$0				$0
Total Direct Cost							$0	$0	$13,978	$0	$13,978
Indirects on Total Direct Cost @ 30%											$699
Profit on Total Direct Cost @ 10%											$1,398
Subtotal 3											$16,074
Health & Safety Monitoring @ 0%											$0
Total Field Cost											$16,074
Contingency on Total Field Cost @ 0%											$0
Engineering on Total Field Cost @ 0%											$0
TOTAL COST											**$16,074**

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater
Alternative 2: Institutional Controls and Groundwater Monitoring
Annual Sampling Cost

Item	Cost per Sampling Round Years 1 thru 30	Item Cost per 5 Years	Notes
Sampling	$11,400		Collect groundwater samples, per sampling period (twice per year with local labor)
Analysis/Water	$6,500		Water samples, per sampling period, (including lab and in-house QA) for TCL VOC's and TAL metals. Monitoring from 20 locations for 30 years.
Report	$4,000		Obtain lab, prepare sampling plan, document sampling events and results
Site Review	$0	$10,000	Review of documents and data evaluation/recommendations, preparation of summary reports for 5-year CERCLA reviews.
TOTALS	$21,900	$10,000	

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater
Alternative 2: Institutional Controls and Groundwater Monitoring
Present Worth Analysis

Year	Capital Cost	Operation and Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$16,074			$16,074	1.000	$16,074
1		$0	$43,800	$43,800	0.935	$40,953
2		$0	$43,800	$43,800	0.873	$38,237
3		$0	$43,800	$43,800	0.816	$35,741
4		$0	$43,800	$43,800	0.763	$33,419
5		$0	$53,800	$53,800	0.713	$38,359
6		$0	$43,800	$43,800	0.666	$29,171
7		$0	$43,800	$43,800	0.623	$27,287
8		$0	$43,800	$43,800	0.582	$25,492
9		$0	$43,800	$43,800	0.544	$23,827
10		$0	$53,800	$53,800	0.508	$27,330
11		$0	$43,800	$43,800	0.475	$20,805
12		$0	$43,800	$43,800	0.444	$19,447
13		$0	$43,800	$43,800	0.415	$18,177
14		$0	$43,800	$43,800	0.388	$16,994
15		$0	$53,800	$53,800	0.362	$19,476
16		$0	$43,800	$43,800	0.339	$14,848
17		$0	$43,800	$43,800	0.317	$13,885
18		$0	$43,800	$43,800	0.296	$12,965
19		$0	$43,800	$43,800	0.277	$12,133
20		$0	$53,800	$53,800	0.258	$13,880
21		$0	$43,800	$43,800	0.242	$10,600
22		$0	$43,800	$43,800	0.226	$9,899
23		$0	$43,800	$43,800	0.211	$9,242
24		$0	$43,800	$43,800	0.197	$8,629
25		$0	$53,800	$53,800	0.184	$9,899
26		$0	$43,800	$43,800	0.172	$7,534
27		$0	$43,800	$43,800	0.161	$7,052
28		$0	$43,800	$43,800	0.150	$6,570
29		$0	$43,800	$43,800	0.141	$6,176
30		$0	$53,800	$53,800	0.131	$7,048
					TOTAL PRESENT WORTH	**$581,148**

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 3: Groundwater Containment of Center of Plume and On-Site Treatment/Recharge
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
1 PROJECT DOCUMENTS/INSTITUTIONAL CONTROLS											
1.1 Prepare Documents & Plans including Permits	500	hr			$40.00		$0	$0	$20,000	$0	$20,000
1.2 Prepare Deed Restrictions	125	hr			$40.00		$0	$0	$5,000	$0	$5,000
2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT											
2.1 Office Trailer (2)	12	mo	$345.00				$4,140	$0	$0	$0	$4,140
2.2 Field Office Support	6	mo		$135.00			$0	$810	$0	$0	$810
2.3 Storage Trailer (1)	6	mo	$85.00				$510	$0	$0	$0	$510
2.4 Construction Survey	1	ls	$18,000.00				$18,000	$0	$0	$0	$18,000
2.5 Equipment Mobilization/Demobilization	8	ea			$45.50	$229.00	$0	$0	$364	$1,832	$2,196
2.6 Install Utilities for Treatment Systems	1	ls	$150,000.00				$150,000	$0	$0	$0	$150,000
2.7 Professional Oversight (5p * 5 days)	26	wk			$4,000.00		$0	$0	$104,000	$0	$104,000
3 DECONTAMINATION											
3.1 Decontamination Trailer (2 for 6 months)	12	mo	$2,275.00				$27,300	$0	$0	$0	$27,300
3.2 Equipment Decon Pad (2 each)	2	ls		$500.00	$450.00	$155.00	$0	$1,000	$900	$310	$2,210
3.3 Decon Water	12,000	gal		$0.20			$0	$2,400	$0	$0	$2,400
3.4 Decon Water Storage Tank, 6,000 gallon (2 for 6 month	12	mo	$600.00				$7,200	$0	$0	$0	$7,200
3.5 Clean Water Storage Tank, 4,000 gallon (2 for 6 months	12	mo	$540.00				$6,480	$0	$0	$0	$6,480
3.6 PPE (6 p * 5 days * 26 weeks)	780	day		$30.00			$0	$23,400	$0	$0	$23,400
3.7 Disposal of Decon Waste (liquid & solid)	6	mo	$900.00				$5,400	$0	$0	$0	$5,400
4 PRE-DESIGN INVESTIGATION/TREATMENT STUDIES											
4.1 Pre-Design Investigation/Aquifer Testing	1	ls	$220,000.00				$220,000	$0	$0	$0	$220,000
4.2 Groundwater Modeling/Fate and Transport Analysis	1	ls	$62,800.00				$62,800	$0	$0	$0	$62,800
4.3 Bench-Scale Treatability Studies	1	ls	$75,000.00				$75,000	$0	$0	$0	$75,000
5 GROUNDWATER EXTRACTION SYSTEM											
5.1 Install Pumping Wells, 4" dia. (41 wells, level C)	9,550	ft	$35.00				$334,250	$0	$0	$0	$334,250
5.2 Well Development (2 hr/well)	82	hr	$35.00				$2,870	$0	$0	$0	$2,870
5.3 21,000 Gallon Steel Tank, Open Top, 3 tanks for 6 mon	18	mo		$1,140.00			$0	$20,520	$0	$0	$20,520
5.4 Transport/Dispose IDW Off-site	50	tanker	$2,575.00				$128,750	$0	$0	$0	$128,750
5.5 Extraction Pumps, 4" dia., 0.3-7 gpm, 321-520 head	22	ea	$2,395.00				$52,690	$0	$0	$0	$52,690
5.6 Extraction Pumps, 4" dia., 21-32 gpm, 121-160 head	16	ea	$1,785.00				$28,560	$0	$0	$0	$28,560
5.7 Extraction Pumps, 4" dia., 21-32 gpm, 61-120 head	10	ea	$1,658.00				$16,580	$0	$0	$0	$16,580
5.8 Vault Boxes and Misc. Piping/Valves at Well Head	41	ea		$399.50	$299.63		$0	$16,380	$12,285	$0	$28,664
5.9 Collection Piping/Fittings, 4"/8" PE	800	lf		$8.21	$16.91	$4.93	$0	$6,568	$13,528	$3,944	$24,040
5.10 Collection Piping/Fittings, 6"/10" PE	1,600	lf		$12.82	$17.49	$5.05	$0	$20,512	$27,984	$8,080	$56,576
5.11 Transfer Piping/Fittings, 6"/10" PE	1,050	lf		$12.82	$17.49	$5.05	$0	$13,461	$18,365	$5,303	$37,128
5.12 Transfer Pumps, 120 gpm, 5 HP	2	ea		$3,999.00	$1,552.00		$0	$7,998	$3,104	$0	$11,102
5.13 Transfer Pumps, 190 gpm, 10 HP	2	ea		$3,587.00	$998.15		$0	$7,174	$1,996	$0	$9,170
5.14 Leak Detection Monitor	3,450	lf		$9.50	$4.75		$0	$32,775	$16,388	$0	$49,163
5.15 Leak Detection Loop	10	ea		$580.00	$1,109.00		$0	$5,800	$11,090	$0	$16,890
5.16 Install New Sump, 8' by 8' by 10' deep	2	ea		$2,425.00	$1,300.00	$560.00	$0	$4,850	$2,600	$1,120	$8,570

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Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
6 GROUNDWATER TREATMENT SYSTEM											
6.1 Building Foundation	1,500	sf	$3.87				$5,805	$0	$0	$0	$5,805
6.2 Treatment Building	1,500	sf	$11.03				$16,545	$0	$0	$0	$16,545
6.3 Building Misc. (doors/vent/misc.)	1	ls	$2,500.00				$2,500	$0	$0	$0	$2,500
6.4 Equalization Tank (12,000 gal)	1	ea		$8,027.00	$1,267.00	$221.47	$0	$8,027	$1,267	$221	$9,515
6.5 Top Mounted Mixer (7.5 HP)	1	ea		$35,438.00	$1,215.00		$0	$35,438	$1,215	$0	$36,653
6.6 Centrifugal Transfer Pump, 400 gpm (15 HP)	2	ea		$3,490.00	$520.33		$0	$6,980	$1,041	$0	$8,021
6.7 Bag Filter, 400 gpm, dual element, 25 micron	1	ea		$7,300.00	$1,095.00		$0	$7,300	$1,095	$0	$8,395
6.8 Air Stripper, 6 ft dia, 46 ft high, packed column	1	ea		$105,230.00	$5,209.00	$881.12	$0	$105,230	$5,209	$881	$111,320
6.9 Centrifugal Transfer Pump, 400 gpm (20 HP)	2	ea		$3,490.00	$520.33		$0	$6,980	$1,041	$0	$8,021
6.10 Offgas Heater, 40 kW	1	ea		$6,428.00	$615.47		$0	$6,428	$615	$0	$7,043
6.11 GAC, Vapor-Phase, 13,600 lbs	2	ea		$52,349.00	$506.82	$84.59	$0	$104,698	$1,014	$169	$105,881
6.12 GAC, Liquid-Phase, 20,000 lbs	2	ea		$77,681.00	$10,890.00	$2,941.00	$0	$155,362	$21,780	$5,882	$183,024
6.13 Instruments and Controls	1	ls		$15,000.00	$700.00		$0	$15,000	$700	$0	$15,700
6.14 Plumb System	1	ls		$6,000.00	$4,000.00		$0	$6,000	$4,000	$0	$10,000
6.15 System Start-Up and Testing	1	ls		$1,000.00	$13,260.00		$0	$1,000	$13,260	$0	$14,260
7 ELECTRICAL COSTS - EXTRACTION AND TREATMENT											
7.1 30 amp Safety Switch, Non-Fused, 600V, Nema 4 Enclo	50	ea		$705.00	$88.00	$0.00	$0	$35,250	$4,400	$0	$39,650
7.2 Electrical Manholes, 4' x 6' x 7'	10	ea		$1,175.00	$670.00	$280.00	$0	$11,750	$6,700	$2,800	$21,250
7.3 Underground Marking Tape, 6" wide	2500	ft		$0.28	$0.26	$0.00	$0	$700	$650	$0	$1,350
7.4 2" PVC, Schedule 40 Conduit	56800	ft		$0.97	$1.47	$0.00	$0	$55,096	$83,496	$0	$138,592
7.5 1/C #8, THHN, Copper Conductor, Stranded	1896	clf		$15.60	$33.00	$0.00	$0	$29,578	$62,568	$0	$92,146
7.6 1/C #10, THHN, Copper Conductor, Stranded	648	clf		$9.30	$26.50	$0.00	$0	$6,026	$17,172	$0	$23,198
7.7 1/C #12, THHN, Copper Conductor, Stranded	1616	clf		$6.05	$24.00	$0.00	$0	$9,777	$38,784	$0	$48,561
7.8 Trench Excavation, 48"D x 36"W	1067	cy		$0.00	$4.04	$4.98	$0	$0	$4,311	$5,314	$9,624
7.9 Trench Bedding, Sand, 6"D	134	cy		$3.50	$3.85	$1.35	$0	$469	$516	$181	$1,166
7.10 Trench Backfill	933	cy		$0.00	$0.50	$0.49	$0	$0	$467	$457	$924
7.11 3/4" PVC Coated Conduit	1000	ft		$3.78	$3.77	$0.00	$0	$3,780	$3,770	$0	$7,550
7.12 3/4" PVC Coated Elbows	300	ea		$9.50	$11.00	$0.00	$0	$2,850	$3,300	$0	$6,150
7.13 3/4" Conduit Hub	100	ea		$23.50	$16.50	$0.00	$0	$2,350	$1,650	$0	$4,000
7.14 Junction Box 6" x 6" x 6", Nema 4	50	ea		$139.00	$66.00	$0.00	$0	$6,950	$3,300	$0	$10,250
7.15 3/4" dia, 10' long, Copper Ground Rod	50	ea		29.50	60.00	0.00	$0	$1,475	$3,000	$0	$4,475
7.16 Bare Copper Wire, #8 Solid	10	clf		$14.00	$24.00	$0.00	$0	$140	$240	$0	$380
7.17 Ground Clamps, Heavy Duty, Bronze	50	ea		$11.70	$33.00	$0.00	$0	$585	$1,650	$0	$2,235
7.18 Heat Trace, Shielded, Self Regulating, 3 W/ft	5	clf		$470.00	$43.82	$0.00	$0	$2,350	$219	$0	$2,569
7.19 Heat Trace Power Connection Box	50	ea		$78.00	$34.43	$0.00	$0	$3,900	$1,722	$0	$5,622
7.20 Heat Trace End Seal	50	ea		$20.25	$6.26	$0.00	$0	$1,013	$313	$0	$1,326
7.21 Motor Control Center, 10 Vert Sections, 42,000 RMS	10	sect		$1,800.00	$330.00	$0.00	$0	$18,000	$3,300	$0	$21,300
7.22 Copper Bus Bars for Item 1 (Add On)	10	sect		$164.00	$0.00	$0.00	$0	$1,640	$0	$0	$1,640
7.23 NEMA 12 Enclosures (Add On)	10	sect		$94.50	$0.00	$0.00	$0	$945	$0	$0	$945

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Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
7.24 Indicating Lights for Starters (Add On)	58	ea		$73.50	$16.50	$0.00	$0	$4,263	$957	$0	$5,220
7.25 Selector Switch for Starters (Add On)	58	ea		$73.50	$16.50	$0.00	$0	$4,263	$957	$0	$5,220
7.26 Motor Control Center, 7 Vert Sections, 42,000 RMS	7	sect		$1,800.00	$330.00	$0.00	$0	$12,600	$2,310	$0	$14,910
7.27 Copper Bus Bars for Item 1 (Add On)	7	sect		$164.00	$0.00	$0.00	$0	$1,148	$0	$0	$1,148
7.28 NEMA 12 Enclosures (Add On)	7	sect		$94.50	$0.00	$0.00	$0	$662	$0	$0	$662
7.29 Indicating Lights for Starters (Add On)	8	ea		$73.50	$16.50	$0.00	$0	$588	$132	$0	$720
7.30 Selector Switch for Starters (Add On)	8	ea		$73.50	$16.50	$0.00	$0	$588	$132	$0	$720
7.31 Transformer, 25KVA	1	ea		$1,175.00	$530.00	$0.00	$0	$1,175	$530	$0	$1,705
7.32 Distribution Panelboard	1	ea		$2,275.00	$1,100.00	$0.00	$0	$2,275	$1,100	$0	$3,375
7.33 Auxiliary Contacts	64	ea		$201.00	$16.50	$0.00	$0	$12,864	$1,056	$0	$13,920
7.34 3/4" Rigid Steel Conduit, Galvanized	2000	ft		$1.81	$3.30	$0.00	$0	$3,620	$6,600	$0	$10,220
7.35 1" Rigid Steel Conduit, Galvanized	200	ft		$2.53	$4.06	$0.00	$0	$506	$812	$0	$1,318
7.36 4" Rigid Steel Conduit, Galvanized	50	ft		$16.50	$13.20	$0.00	$0	$825	$660	$0	$1,485
7.37 1/C #12 THHN Copper Conductor	200	clf		$6.05	$24.00	$0.00	$0	$1,210	$4,800	$0	$6,010
7.38 1/C #10 THHN Copper Conductor	5	clf		$9.30	$26.50	$0.00	$0	$47	$133	$0	$179
7.39 1/C #8 THHN Copper Conductor	5	clf		$15.60	$33.00	$0.00	$0	$78	$165	$0	$243
7.40 1/C #500 KCMIL Copper Conductor	10	clf		$425.00	$165.00	$0.00	$0	$4,250	$1,650	$0	$5,900
7.41 Treatment Plant Lighting/Distr. System	5000	sf		$2.85	$4.33	$0.00	$0	$14,250	$21,650	$0	$35,900
7.42 30 amp, Safety Switch, 600V, Non-Fused	14	ea		$181.00	$85.00	$0.00	$0	$2,534	$1,190	$0	$3,724
7.43 Treatment Plant Lightning System	1	pkg		$10,000.00	$3,000.00	$0.00	$0	$10,000	$3,000	$0	$13,000
7.44 Treatment Plant Grounding System	1	pkg		$5,000.00	$2,000.00	$0.00	$0	$5,000	$2,000	$0	$7,000
8 GROUNDWATER RECHARGE											
8.1 Injection Well Installation, 40 wells	5,000	ft	$35.00				$175,000	$0	$0	$0	$175,000
8.2 Well Development (2 hr/well)	80	hr	$35.00				$2,800	$0	$0	$0	$2,800
8.3 Recharge Piping, 6" PE, buried	4,500	ft		$2.94	$5.58	$2.80	$0	$13,230	$25,110	$12,600	$50,940
9 SITE RESTORATION											
9.1 Top Dress Soil	1,111	sy		$2.91	$1.53		$0	$3,233	$1,700	$0	$4,933
9.2 Fine Grading & Seeding	1,111	sy		$0.29	$1.13	$0.20	$0	$322	$1,255	$222	$1,800
9.3 Pavement Repair/Replacement	10	sy		$6.05	$16.10	$1.91	$0	$61	$161	$19	$241
Subtotal							$1,343,180	$916,305	$609,426	$49,335	$2,918,246
Local Area Adjustments							100.0%	100.0%	124.8%	124.8%	
Subtotal							$1,343,180	$916,305	$760,564	$61,570	$3,081,619
Overhead on Labor Cost @ 30%									$228,169		$228,169
G & A on Labor Cost @ 10%									$76,056		$76,056
G & A on Material Cost @ 10%								$91,630			$91,630
G & A on Subcontract Cost @ 10%							$134,318				$134,318

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 3: Groundwater Containment of Center of Plume and On-Site Treatment/Recharge
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
Total Direct Cost							$1,477,498	$1,007,935	$1,064,789	$61,570	$3,611,793
Indirects on Total Direct Cost @ 30%											$1,083,538
Profit on Total Direct Cost @ 10%											$361,179
Subtotal											$5,056,510
Health & Safety Monitoring @ 2%											$101,130
Total Field Cost											$5,157,640
Contingency on Total Field Cost @ 20%											$1,031,528
Engineering on Total Field Cost @ 10%											$515,764
TOTAL COST											**$6,704,932**

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 3: Groundwater Containment of Center of Plume and On-Site Treatment/Recharge
Operation and Maintenance Costs per Year

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
YEAR 1						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment & Electrical System Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Costt
4	Recharge System Maintenance, Labor & Supplies	1	ls	$2,547.00	$2,547	5% of Installation Cost
5	Changeout/Regeneration of Spent Carbon	680,000	lb.	$3.00	$2,040,000	Replace canister 50 times
6	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
7	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
8	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during year 1				$2,237,076	
YEAR 2						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment & Electrical System Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Recharge System Maintenance, Labor & Supplies	1	ls	$2,547.00	$2,547	5% of Installation Cost
5	Changeout/Regeneration of Spent Carbon	476,000	lb.	$3.00	$1,428,000	Replace canister 35 times
6	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
7	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
8	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during year 2				$1,625,076	
YEAR 3						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment & Electrical System Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Recharge System Maintenance, Labor & Supplies	1	ls	$2,547.00	$2,547	5% of Installation Cost
5	Changeout/Regeneration of Spent Carbon	204,000	lb.	$3.00	$612,000	Replace canister 15 times
6	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
7	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
8	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during year 3				$809,076	

CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 3: Groundwater Containment of Center of Plume and On-Site Treatment/Recharge
Operation and Maintenance Costs per Year

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
YEAR 4						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment & Electrical System Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Recharge System Maintenance, Labor & Supplies	1	ls	$2,547.00	$2,547	5% of Installation Cost
5	Changeout/Regeneration of Spent Carbon	108,800	lb.	$3.00	$326,400	Replace canister 8 times
6	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
7	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
8	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during year 4				$523,476	
YEARS 5 THROUGH 10						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment & Electrical System Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Recharge System Maintenance, Labor & Supplies	1	ls	$2,547.00	$2,547	5% of Installation Cost
5	Changeout/Regeneration of Spent Carbon	54,400	lb.	$3.00	$163,200	Replace canister 4 times
6	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
7	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
8	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during years 5-10				$360,276	

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 3: Groundwater Containment of Center of Plume and On-Site Treatment/Recharge
Operation and Maintenance Costs per Year

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
YEARS 11 THROUGH 20						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment & Electrical System Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Recharge System Maintenance, Labor & Supplies	1	ls	$2,547.00	$2,547	5% of Installation Cost
5	Changeout/Regeneration of Spent Carbon	27,200	lb.	$3.00	$81,600	Replace canister 2 times
6	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
7	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
8	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during years 11-20				$278,676	
YEARS 21 THROUGH 30						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment & Electrical System Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Recharge System Maintenance, Labor & Supplies	1	ls	$2,547.00	$2,547	5% of Installation Cost
5	Changeout/Regeneration of Spent Carbon	13,600	lb.	$3.00	$40,800	Replace canister 1 time
6	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
7	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
8	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during years 21-30				$237,876	

CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 3: Groundwater Containment of Center of Plume and On-Site Treatment/Recharge
Annual Sampling Cost

Item	Cost per Sampling Round Years 1 thru 30*	Item Cost per 5 Years	Notes
Sampling	$11,400		Collect groundwater samples, per sampling period (twice per year with local labor)
Analysis/Water	$6,500		Water samples, per sampling period, (including lab and in-house QA) for TCL VOC's and TAL metals. Monitoring from 20 locations for 30 years.
Report	$4,000		Obtain lab, prepare sampling plan, document sampling events and results
Maintenance		$15,000	Extraction well inspection, cleaning, antifouling, and maintenance
Site Review	$0	$10,000	Review of documents and data evaluation/recommendations; preparation of summary reports for 5-year CERCLA reviews
TOTALS	$21,900	$25,000	

* Semi-annually years 1 through 30

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 3: Groundwater Containment of Center of Plume and On-Site Treatment/Recharge
Present Worth Analysis

Year	Capital Cost	Operation and Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$6,704,932			$6,704,932	1.000	$6,704,932
1		$2,237,076	$43,800	$2,280,876	0.935	$2,132,619
2		$1,625,076	$43,800	$1,668,876	0.873	$1,456,929
3		$809,076	$43,800	$852,876	0.816	$695,947
4		$523,476	$43,800	$567,276	0.763	$432,831
5		$360,276	$68,800	$429,076	0.713	$305,931
6		$360,276	$43,800	$404,076	0.666	$269,115
7		$360,276	$43,800	$404,076	0.623	$251,739
8		$360,276	$43,800	$404,076	0.582	$235,172
9		$360,276	$43,800	$404,076	0.544	$219,817
10		$360,276	$68,800	$429,076	0.508	$217,971
11		$278,676	$43,800	$322,476	0.475	$153,176
12		$278,676	$43,800	$322,476	0.444	$143,179
13		$278,676	$43,800	$322,476	0.415	$133,827
14		$278,676	$43,800	$322,476	0.388	$125,121
15		$278,676	$68,800	$347,476	0.362	$125,786
16		$278,676	$43,800	$322,476	0.339	$109,319
17		$278,676	$43,800	$322,476	0.317	$102,225
18		$278,676	$43,800	$322,476	0.296	$95,453
19		$278,676	$43,800	$322,476	0.277	$89,326
20		$278,676	$68,800	$347,476	0.258	$89,649
21		$237,876	$43,800	$281,676	0.242	$68,166
22		$237,876	$43,800	$281,676	0.226	$63,659
23		$237,876	$43,800	$281,676	0.211	$59,434
24		$237,876	$43,800	$281,676	0.197	$55,490
25		$237,876	$68,800	$306,676	0.184	$56,428
26		$237,876	$43,800	$281,676	0.172	$48,448
27		$237,876	$43,800	$281,676	0.161	$45,350
28		$237,876	$43,800	$281,676	0.150	$42,251
29		$237,876	$43,800	$281,676	0.141	$39,716
30		$237,876	$68,800	$306,676	0.131	$40,175

TOTAL PRESENT WORTH **$14,609,180**

CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 4: Groundwater Containment of Center of Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
1 PROJECT DOCUMENTS/INSTITUTIONAL CONTROLS											
1.1 Prepare Documents & Plans including Permits	500	hr			$40.00		$0	$0	$20,000	$0	$20,000
1.2 Prepare Deed Restrictions	125	hr			$40.00		$0	$0	$5,000	$0	$5,000
2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT											
2.1 Office Trailer (2)	12	mo	$345.00				$4,140	$0	$0	$0	$4,140
2.2 Field Office Support	6	mo		$135.00			$0	$810	$0	$0	$810
2.3 Storage Trailer (1)	6	mo	$85.00				$510	$0	$0	$0	$510
2.4 Construction Survey	1	ls	$18,000.00				$18,000	$0	$0	$0	$18,000
2.5 Equipment Mobilization/Demobilization	8	ea			$45.50	$229.00	$0	$0	$364	$1,832	$2,196
2.6 Install Utilities for Treatment Systems	1	ls	$150,000.00				$150,000	$0	$0	$0	$150,000
2.7 Professional Oversight (5p * 5 days)	26	wk			$4,000.00		$0	$0	$104,000	$0	$104,000
3 DECONTAMINATION											
3.1 Decontamination Trailer (2 for 6 months)	12	mo	$2,275.00				$27,300	$0	$0	$0	$27,300
3.2 Equipment Decon Pad (2 each)	2	ls		$500.00	$450.00	$155.00	$0	$1,000	$900	$310	$2,210
3.3 Decon Water	12,000	gal		$0.20			$0	$2,400	$0	$0	$2,400
3.4 Decon Water Storage Tank, 6,000 gallon (2 for 6 months	12	mo	$600.00				$7,200	$0	$0	$0	$7,200
3.5 Clean Water Storage Tank, 4,000 gallon (2 for 6 months)	12	mo	$540.00				$6,480	$0	$0	$0	$6,480
3.6 PPE (6 p * 5 days * 26 weeks)	780	day		$30.00			$0	$23,400	$0	$0	$23,400
3.7 Disposal of Decon Waste (liquid & solid)	6	mo	$900.00				$5,400	$0	$0	$0	$5,400
4 PRE-DESIGN INVESTIGATION/TREATMENT STUDIES											
4.1 Pre-Design Investigation/Aquifer Testing	1	ls	$220,000.00				$220,000	$0	$0	$0	$220,000
4.2 Groundwater Modeling/Fate and Transport Analysis	1	ls	$62,800.00				$62,800	$0	$0	$0	$62,800
4.3 Bench-Scale Treatability Studies	1	ls	$75,000.00				$75,000	$0	$0	$0	$75,000
5 GROUNDWATER EXTRACTION SYSTEM MODIFICATION											
5.1 Install Pumping Wells, 4" dia. (41 wells, level C)	9,550	ft	$35.00				$334,250	$0	$0	$0	$334,250
5.2 Well Development (2 hr/well)	82	hr	$35.00				$2,870	$0	$0	$0	$2,870
5.3 21,000 Gallon Steel Tank, Open Top, 3 tanks for 6 mont	18	mo		$1,140.00			$0	$20,520	$0	$0	$20,520
5.4 Transport/Dispose IDW Off-site	50	tanker	$2,575.00				$128,750	$0	$0	$0	$128,750
5.5 Extraction Pumps, 4" dia., 0.3-7 gpm, 321-520 head	22	ea	$2,395.00				$52,690	$0	$0	$0	$52,690
5.6 Extraction Pumps, 4" dia., 21-32 gpm, 121-160 head	16	ea	$1,785.00				$28,560	$0	$0	$0	$28,560
5.7 Extraction Pumps, 4" dia., 21-32 gpm, 61-120 head	10	ea	$1,658.00				$16,580	$0	$0	$0	$16,580
5.8 *Vault Boxes and Misc. Piping/Valves at Well Head*	41	ea		$399.50	$299.63		$0	$16,380	$12,285	$0	$28,664
5.9 Collection Piping/Fittings, 4"/8" PE	800	lf		$8.21	$16.91	$4.93	$0	$6,568	$13,528	$3,944	$24,040
5.10 Collection Piping/Fittings, 6"/10" PE	1,600	lf		$12.82	$17.49	$5.05	$0	$20,512	$27,984	$8,080	$56,576
5.11 Transfer Piping/Fittings, 6"/10" PE	1,050	lf		$12.82	$17.49	$5.05	$0	$13,461	$18,365	$5,303	$37,128
5.12 Transfer Pumps, 120 gpm, 5 HP	2	ea		$3,999.00	$1,552.00		$0	$7,998	$3,104	$0	$11,102
5.13 *Transfer Pumps, 190 gpm, 10 HP*	2	ea		$3,587.00	$998.15		$0	$7,174	$1,996	$0	$9,170
5.14 Leak Detection Monitor	3,450	lf		$9.50	$4.75		$0	$32,775	$16,388	$0	$49,163

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
5.15 Leak Detection Loop	10	ea		$580.00	$1,109.00		$0	$5,800	$11,090	$0	$16,890
5.16 Highway/Railroad Boring	30	lf	$305.00				$9,150	$0	$0	$0	$9,150
5.17 ~~Boring Preparation (pits, mob/demob)~~	1	~~ls~~	~~$6,000.00~~				~~$6,000~~	~~$0~~	~~$0~~	$0	$6,000
5.18 Install New Sump, 8' by 8' by 10' deep	2	ea		$2,425.00	$1,300.00	$560.00	$0	$4,850	$2,600	$1,120	$8,570
6 GROUNDWATER TREATMENT SYSTEM											
6.1 Building Foundation	1,500	sf	$3.87				$5,805	$0	$0	$0	$5,805
6.2 Treatment Building	1,500	sf	$11.03				$16,545	$0	$0	$0	$16,545
6.3 Building Misc. (doors/vent/insulation/misc.)	1	ls	$2,500.00				$2,500	$0	$0	$0	$2,500
6.4 Equalization Tank (12,000 gal)	1	ea		$8,027.00	$1,267.00	$221.47	$0	$8,027	$1,267	$221	$9,515
6.5 Top Mounted Mixer (7.5 HP)	1	ea		$35,438.00	$1,215.00		$0	$35,438	$1,215	$0	$36,653
6.6 Centrifugal Transfer Pump, 400 gpm (15 HP)	2	ea		$3,490.00	$520.33		$0	$6,980	$1,041	$0	$8,021
6.7 Bag Filter, 400 gpm, dual element, 25 micron	1	ea		$7,300.00	$1,095.00		$0	$7,300	$1,095	$0	$8,395
6.8 Air Stripper, 6 ft dia, 46 ft high, packed column	1	ea		$105,230.00	$5,209.00	$881.12	$0	$105,230	$5,209	$881	$111,320
6.9 Centrifugal Transfer Pump, 400 gpm (20 HP)	2	ea		$3,490.00	$520.33		$0	$6,980	$1,041	$0	$8,021
6.10 Offgas Heater, 40 kW	1	ea		$6,428.00	$615.47		$0	$6,428	$615	$0	$7,043
6.11 GAC, vapor-phase, 13,600 lbs	2	ea		$52,349.00	$506.82	$84.59	$0	$104,698	$1,014	$169	$105,881
6.12 GAC, liquid-phase, 20,000 lbs	2	ea		$77,681.00	$10,890.00	$2,941.00	$0	$155,362	$21,780	$5,882	$183,024
6.13 Instruments and Controls	1	ls		$15,000.00	$700.00		$0	$15,000	$700	$0	$15,700
6.14 Plumb System	1	ls		$6,000.00	$4,000.00		$0	$6,000	$4,000	$0	$10,000
6.15 System Start-Up and Testing	1	ls		$1,000.00	$13,260.00		$0	$1,000	$13,260	$0	$14,260
7 ELECTRICAL COSTS - EXTRACTION AND TREATMENT											
7.1 30 amp Safety Switch, Non-Fused, 600V, Nema 4 Enclos	50	ea		$705.00	$88.00	$0.00	$0	$35,250	$4,400	$0	$39,650
7.2 Electrical Manholes, 4' x 6' x 7'	10	ea		$1,175.00	$670.00	$280.00	$0	$11,750	$6,700	$2,800	$21,250
7.3 Underground Marking Tape, 6" wide	2500	ft		$0.28	$0.26	$0.00	$0	$700	$650	$0	$1,350
7.4 2" PVC, Schedule 40 Conduit	56800	ft		$0.97	$1.47	$0.00	$0	$55,096	$83,496	$0	$138,592
7.5 1/C #8, THHN, Copper Conductor, Stranded	1896	clf		$15.60	$33.00	$0.00	$0	$29,578	$62,568	$0	$92,146
7.6 1/C #10, THHN, Copper Conductor, Stranded	648	clf		$9.30	$26.50	$0.00	$0	$6,026	$17,172	$0	$23,198
7.7 1/C #12, THHN, Copper Conductor, Stranded	1616	clf		$6.05	$24.00	$0.00	$0	$9,777	$38,784	$0	$48,561
7.8 Trench Excavation, 48"D x 36"W	1067	cy		$0.00	$4.04	$4.98	$0	$0	$4,311	$5,314	$9,624
7.9 Trench Bedding, Sand, 6"D	134	cy		$3.50	$3.85	$1.35	$0	$469	$516	$181	$1,166
7.10 Trench Backfill	933	cy		$0.00	$0.50	$0.49	$0	$0	$467	$457	$924
7.11 3/4" PVC Coated Conduit	1000	ft		$3.78	$3.77	$0.00	$0	$3,780	$3,770	$0	$7,550
7.12 3/4" PVC Coated Elbows	300	ea		$9.50	$11.00	$0.00	$0	$2,850	$3,300	$0	$6,150
7.13 3/4" Conduit Hub	100	ea		$23.50	$16.50	$0.00	$0	$2,350	$1,650	$0	$4,000
7.14 Junction Box 6" x 6" x 6", Nema 4	50	ea		$139.00	$66.00	$0.00	$0	$6,950	$3,300	$0	$10,250
7.15 3/4" dia, 10' long, Copper Ground Rod	50	ea		29.50	60.00	0.00	$0	$1,475	$3,000	$0	$4,475
7.16 Bare Copper Wire, #8 Solid	10	clf		$14.00	$24.00	$0.00	$0	$140	$240	$0	$380
7.17 Ground Clamps, Heavy Duty, Bronze	50	ea		$11.70	$33.00	$0.00	$0	$585	$1,650	$0	$2,235

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Item	Quantity	Unit	Unit Cost				Total Cost				Total Direct
			Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	Cost
7.18 Heat Trace, Shielded, Self Regulating, 3 W/ft	5	clf		$470.00	$43.82	$0.00	$0	$2,350	$219	$0	$2,569
7.19 Heat Trace Power Connection Box	50	ea		$78.00	$34.43	$0.00	$0	$3,900	$1,722	$0	$5,622
7.20 Heat Trace End Seal	50	ea		$20.25	$6.26	$0.00	$0	$1,013	$313	$0	$1,326
7.21 Motor Control Center, 10 Vert Sections, 42,000 RMS	10	sect		$1,800.00	$330.00	$0.00	$0	$18,000	$3,300	$0	$21,300
7.22 Copper Bus Bars for Item 1 (Add On)	10	sect		$164.00	$0.00	$0.00	$0	$1,640	$0	$0	$1,640
7.23 NEMA 12 Enclosures (Add On)	10	sect		$94.50	$0.00	$0.00	$0	$945	$0	$0	$945
7.24 Indicating Lights for Starters (Add On)	58	ea		$73.50	$16.50	$0.00	$0	$4,263	$957	$0	$5,220
7.25 Selector Switch for Starters (Add On)	58	ea		$73.50	$16.50	$0.00	$0	$4,263	$957	$0	$5,220
7.26 Motor Control Center, 7 Vert Sections, 42,000 RMS	7	sect		$1,800.00	$330.00	$0.00	$0	$12,600	$2,310	$0	$14,910
7.27 Copper Bus Bars for Item 1 (Add On)	7	sect		$164.00	$0.00	$0.00	$0	$1,148	$0	$0	$1,148
7.28 NEMA 12 Enclosures (Add On)	7	sect		$94.50	$0.00	$0.00	$0	$662	$0	$0	$662
7.29 Indicating Lights for Starters (Add On)	8	ea		$73.50	$16.50	$0.00	$0	$588	$132	$0	$720
7.30 Selector Switch for Starters (Add On)	8	ea		$73.50	$16.50	$0.00	$0	$588	$132	$0	$720
7.31 Transformer, 25KVA	1	ea		$1,175.00	$530.00	$0.00	$0	$1,175	$530	$0	$1,705
7.32 Distribution Panelboard	1	ea		$2,275.00	$1,100.00	$0.00	$0	$2,275	$1,100	$0	$3,375
7.33 Auxiliary Contacts	64	ea		$201.00	$16.50	$0.00	$0	$12,864	$1,056	$0	$13,920
7.34 3/4" Rigid Steel Conduit, Galvanized	2000	ft		$1.81	$3.30	$0.00	$0	$3,620	$6,600	$0	$10,220
7.35 1" Rigid Steel Conduit, Galvanized	200	ft		$2.53	$4.06	$0.00	$0	$506	$812	$0	$1,318
7.36 4" Rigid Steel Conduit, Galvanized	50	ft		$16.50	$13.20	$0.00	$0	$825	$660	$0	$1,485
7.37 1/C #12 THHN Copper Conductor	200	clf		$6.05	$24.00	$0.00	$0	$1,210	$4,800	$0	$6,010
7.38 1/C #10 THHN Copper Conductor	5	clf		$9.30	$26.50	$0.00	$0	$47	$133	$0	$179
7.39 1/C #8 THHN Copper Conductor	5	clf		$15.60	$33.00	$0.00	$0	$78	$165	$0	$243
7.40 1/C #500 KCMIL Copper Conductor	10	clf		$425.00	$165.00	$0.00	$0	$4,250	$1,650	$0	$5,900
7.41 Treatment Plant Lighting/Distr. System	5000	sf		$2.85	$4.33	$0.00	$0	$14,250	$21,650	$0	$35,900
7.42 30 amp, Safety Switch, 600V, Non-Fused	14	ea		$181.00	$85.00	$0.00	$0	$2,534	$1,190	$0	$3,724
7.43 Treatment Plant Lightning System	1	pkg		$10,000.00	$3,000.00	$0.00	$0	$10,000	$3,000	$0	$13,000
7.44 Treatment Plant Grounding System	1	pkg		$5,000.00	$2,000.00	$0.00	$0	$5,000	$2,000	$0	$7,000
8 GROUNDWATER DISCHARGE TO WEST BRANCH											
8.1 Discharge Piping, 8" PE	2,000	ft		$5.05	$6.41	$3.20	$0	$10,100	$12,820	$6,400	$29,320
8.2 Outfall Structure (Headwall)	1	ea		$440.00	$1,100.00	$375.00	$0	$440	$1,100	$375	$1,915
9 SITE RESTORATION											
9.1 Top Dress Soil	2,500	sy		$2.91	$1.53		$0	$7,275	$3,825	$0	$11,100
9.2 Fine Grading & Seeding	2,500	sy		$0.29	$1.13	$0.20	$0	$725	$2,825	$500	$4,050
9.3 Pavement Repair/Replacement	10	sy		$6.05	$16.10	$1.91	$0	$61	$161	$19	$241
Subtotal							$1,180,530	$918,059	$601,931	$43,788	$2,744,308

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 4: Groundwater Containment of Center of Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
Local Area Adjustments							100.0%	100.0%	124.8%	124.8%	
Subtotal							$1,180,530	$918,059	$751,210	$54,648	$2,904,446
Overhead on Labor Cost @ 30%									$225,363		$225,363
G & A on Labor Cost @ 10%									$75,121		$75,121
G & A on Material Cost @ 10%								$91,806			$91,806
G & A on Subcontract Cost @ 10%							$118,053				$118,053
Total Direct Cost							$1,298,583	$1,009,865	$1,051,693	$54,648	$3,414,789
Indirects on Total Direct Cost @ 30%											$1,024,437
Profit on Total Direct Cost @ 10%											$341,479
Subtotal											$4,780,705
Health & Safety Monitoring @ 2%											$95,614
Total Field Cost											$4,876,319
Contingency on Total Field Cost @ 20%											$975,264
Engineering on Total Field Cost @ 10%											$487,632
TOTAL COST											**$6,339,215**

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 4: Groundwater Containment of Center of Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Operation and Maintenance Costs per Year

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
YEAR 1						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment System and Electrical Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Changeout/Regeneration of Spent Carbon	680,000	lb.	$3.00	$2,040,000	Replace canister 50 times
5	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
6	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
7	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during year 1				$2,234,529	
YEAR 2						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment System and Electrical Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Changeout/Regeneration of Spent Carbon	476,000	lb.	$3.00	$1,428,000	Replace canister 35 times
5	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
6	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
7	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during year 2				$1,622,529	
YEAR 3						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment System and Electrical Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Changeout/Regeneration of Spent Carbon	204,000	lb.	$3.00	$612,000	Replace canister 15 times
5	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
6	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
7	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during year 3				$806,529	

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 4: Groundwater Containment of Center of Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Operation and Maintenance Costs per Year

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
YEAR 4						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment System and Electrical Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Changeout/Regeneration of Spent Carbon	108,800	lb.	$3.00	$326,400	Replace canister 8 times
5	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
6	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
7	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during year 4				$520,929	
YEARS 5 THROUGH 10						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment System and Electrical Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Changeout/Regeneration of Spent Carbon	54,400	lb.	$3.00	$163,200	Replace canister 4 times
5	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
6	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
7	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during years 5-10				$357,729	

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 4: Groundwater Containment of Center of Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Operation and Maintenance Costs per Year

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
YEARS 11 THROUGH 20						
1	*Energy - Electric*	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment System and Electrical Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Changeout/Regeneration of Spent Carbon	27,200	lb.	$3.00	$81,600	Replace canister 2 times
5	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
6	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
7	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during years 11-20				$276,129	
YEARS 21 THROUGH 30						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment System and Electrical Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	*Changeout/Regeneration of Spent Carbon*	13,600	lb.	$3.00	$40,800	Replace canister 1 time
5	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
6	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
7	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during years 21-30				$235,329	

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 4: Groundwater Containment of Center of Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Annual Sampling Cost

Item	Cost per Sampling Round Years 1 thru 30*	Item Cost per 5 Years	Notes
Sampling	$11,400		Collect groundwater samples, per sampling period (twice per year with local labor)
Analysis/Water	$6,500		Water samples, per sampling period, (including lab and in-house QA) for TCL VOC's and TAL metals. Monitoring from 20 locations for 30 years.
Report	$4,000		Obtain lab, prepare sampling plan, document sampling events and results
Maintenance		$15,000	Extraction well inspection, cleaning, antifouling, and maintenance
Site Review	$0	$10,000	Review of documents and data evaluation/recommendations; preparation of summary reports for 5-year CERCLA reviews
TOTALS	$21,900	$25,000	

* Semi-annually years 1 through 30

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 4: Groundwater Containment of Center of Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Present Worth Analysis

Year	Capital Cost	Operation and Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$6,339,215			$6,339,215	1.000	$6,339,215
1		$2,234,529	$43,800	$2,278,329	0.935	$2,130,237
2		$1,622,529	$43,800	$1,666,329	0.873	$1,454,705
3		$806,529	$43,800	$850,329	0.816	$693,868
4		$520,929	$43,800	$564,729	0.763	$430,888
5		$357,729	$68,800	$426,529	0.713	$304,115
6		$357,729	$43,800	$401,529	0.666	$267,418
7		$357,729	$43,800	$401,529	0.623	$250,152
8		$357,729	$43,800	$401,529	0.582	$233,690
9		$357,729	$43,800	$401,529	0.544	$218,432
10		$357,729	$68,800	$426,529	0.508	$216,677
11		$276,129	$43,800	$319,929	0.475	$151,966
12		$276,129	$43,800	$319,929	0.444	$142,048
13		$276,129	$43,800	$319,929	0.415	$132,770
14		$276,129	$43,800	$319,929	0.388	$124,132
15		$276,129	$68,800	$344,929	0.362	$124,864
16		$276,129	$43,800	$319,929	0.339	$108,456
17		$276,129	$43,800	$319,929	0.317	$101,417
18		$276,129	$43,800	$319,929	0.296	$94,699
19		$276,129	$43,800	$319,929	0.277	$88,620
20		$276,129	$68,800	$344,929	0.258	$88,992
21		$235,329	$43,800	$279,129	0.242	$67,549
22		$235,329	$43,800	$279,129	0.226	$63,083
23		$235,329	$43,800	$279,129	0.211	$58,896
24		$235,329	$43,800	$279,129	0.197	$54,988
25		$235,329	$68,800	$304,129	0.184	$55,960
26		$235,329	$43,800	$279,129	0.172	$48,010
27		$235,329	$43,800	$279,129	0.161	$44,940
28		$235,329	$43,800	$279,129	0.150	$41,869
29		$235,329	$43,800	$279,129	0.141	$39,357
30		$235,329	$68,800	$304,129	0.131	$39,841

TOTAL PRESENT WORTH **$14,211,857**

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 5: In-Situ Treatments of the Residual Plume, Institutional Controls, and Monitoring
Capital Cost

Item	Quantity	Unit	Unit Cost				Total Cost				Total Direct
			Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	Cost
1 PROJECT DOCUMENTS/INSTITUTIONAL CONTROLS											
1.1 Prepare Documents & Plans including Permits	200	hr			$40.00		$0	$0	$8,000	$0	$8,000
1.2 Prepare Deed Restrictions	125	hr			$40.00		$0	$0	$5,000	$0	$5,000
2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT											
2.1 Office Trailer (2)	12	mo	$345.00				$4,140	$0	$0	$0	$4,140
2.2 Field Office Support	6	mo		$135.00			$0	$810	$0	$0	$810
2.3 Storage Trailer (1)	6	mo	$85.00				$510	$0	$0	$0	$510
2.4 Construction Survey	1	ls	$1,000.00				$1,000	$0	$0	$0	$1,000
2.5 Equipment Mobilization/Demobilization	5	ea			$45.50	$229.00	$0	$0	$228	$1,145	$1,373
2.6 Site Utilities Installation	1	ls	$150,000.00				$150,000	$0	$0	$0	$150,000
2.7 Site Utilities	6	mo	$1,000.00				$6,000	$0	$0	$0	$6,000
2.8 Professional Oversight (5p * 5 days)	26	wk			$4,000.00		$0	$0	$104,000	$0	$104,000
3 DECONTAMINATION											
3.1 Decontamination Trailer	6	mo	$2,275.00				$13,650	$0	$0	$0	$13,650
3.2 Equipment Decon Pad	1	ls		$500.00	$450.00	$155.00	$0	$500	$450	$155	$1,105
3.3 Decon Water	6,000	gal		$0.20			$0	$1,200	$0	$0	$1,200
3.4 Decon Water Storage Tank, 6,000 gallon	6	mo	$600.00				$3,600	$0	$0	$0	$3,600
3.5 Clean Water Storage Tank, 4,000 gallon	6	mo	$540.00				$3,240	$0	$0	$0	$3,240
3.6 PPE (6 p * 5 days * 26 weeks)	780	day		$30.00			$0	$23,400	$0	$0	$23,400
3.7 Pre-Disposal of Decon Waste (liquid & solid)	6	mo	$900.00				$5,400	$0	$0	$0	$5,400
4 PRE-DESIGN INVESTIGATION											
4.1 Pre-Design Investigation/Aquifer Testing	1	ls	$75,000.00				$75,000	$0	$0	$0	$75,000
5 TREATMENT STUDY											
5.1 Bench Test	1	ea	$3,500.00				$3,500	$0	$0	$0	$3,500
5.2 Develop Work Plan	1	ls	$7,500.00				$7,500	$0	$0	$0	$7,500
5.3 Technical Report	1	ls	$7,500.00				$7,500	$0	$0	$0	$7,500
5.4 Stainless Steel Application Wells, 2-in, 2@80', Level B	160	ft	$70.00				$11,200	$0	$0	$0	$11,200
5.5 Stainless Steel Application Wells, 2-in, 2@300', Level B	600	ft	$70.00				$42,000	$0	$0	$0	$42,000
5.6 Two-Cycle Pilot Test, Areas	1	ls	$83,750.00				$83,750	$0	$0	$0	$83,750
6 IN-SITU OXIDATION (CLEANOX®)											
6.1 Install Application Wells (150 @ 20' - 400')	18,750	ft	$70.00				$1,312,500	$0	$0	$0	$1,312,500
6.2 Well Development (2 hr/well)	300	hr	$35.00				$10,500	$0	$0	$0	$10,500
6.3 21,000 Gallon Steel Tank, Open Top, 3 tanks for 3 months	9	mo		$1,140.00			$0	$10,260	$0	$0	$10,260
6.4 Transport/Dispose IDW Off-site	150	tanker	$2,575.00				$386,250	$0	$0	$0	$386,250
6.5 CleanOX® Treatment	1	ls	$1,875,000.00				$1,875,000	$0	$0	$0	$1,875,000
7 SAMPLING AND ANALYSIS OF TREATMENT MONITORING WELLS											
7.1 Install Monitoring Wells (5 @ 400 ft)	2,000	ft	$35.00				$70,000	$0	$0	$0	$70,000
7.2 Well Development (2 hr/well)	10	hr	$35.00				$350	$0	$0	$0	$350
7.3 Well Sampling, 5 wells per month for 6 months	6	ea	$4,100.00				$24,600	$0	$0	$0	$24,600
7.4 Analysis, TCL VOCs and TAL metals, 5 wells/6 months	30	ea	$325.00				$9,750	$0	$0	$0	$9,750

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 5: In-Situ Treatments of the Residual Plume, Institutional Controls, and Monitoring
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
Subtotal							$4,106,940	$36,170	$117,678	$1,300	$4,262,088
Local Area Adjustments							100.0%	100.0%	124.8%	124.8%	
Subtotal							$4,106,940	$36,170	$146,862	$1,622	$4,291,594
Overhead on Labor Cost @ 30%									$44,058		$44,058
G & A on Labor Cost @ 10%									$14,686		$14,686
G & A on Material Cost @ 10%								$3,617			$3,617
G & A on Subcontract Cost @ 10%							$410,694				$410,694
Total Direct Cost							$4,517,634	$39,787	$205,606	$1,622	$4,764,650
Indirects on Total Direct Cost @ 15%											$714,697
Profit on Total Direct Cost @ 10%											$476,465
Subtotal											$5,955,812
Health & Safety Monitoring @ 2%											$119,116
Total Field Cost											$6,074,928
Contingency on Total Field Cost @ 20%											$1,214,986
Engineering on Total Field Cost @ 5%											$303,746
TOTAL COST											$7,593,660

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 5: In-Situ Treatments of the Residual Plume, Institutional Controls, and Monitoring
Annual Sampling Cost

Item	Cost per Sampling Round Years 1 thru 30*	Item Cost per 5 Years	Notes
Sampling	$11,400		Collect groundwater samples, per sampling period (twice per year with local labor)
Analysis/Water	$6,500		Water samples, per sampling period, (including lab and in-house QA) for TCL VOC's and TAL metals. Monitoring from 20 locations for 30 years.
Report	$4,000		Obtain lab, prepare sampling plan, document sampling events and results
Maintenance		$15,000	Injection well inspection, cleaning, antifouling, and maintenance
Site Review		$20,000	Review of documents and data evaluation/recommendations; preparation of summary reports for 5-year CERCLA reviews
TOTALS	$21,900	$35,000	

*Twice per year

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 5: In-Situ Treatments of the Residual Plume, Institutional Controls, and Monitoring

Present Worth Analysis

Year	Capital Cost	Operation and Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$7,593,660			$7,593,660	1.000	$7,593,660
1		$0	$43,800	$43,800	0.935	$40,953
2		$0	$43,800	$43,800	0.873	$38,237
3		$0	$43,800	$43,800	0.816	$35,741
4		$0	$43,800	$43,800	0.763	$33,419
5		$0	$78,800	$78,800	0.713	$56,184
6		$0	$43,800	$43,800	0.666	$29,171
7		$0	$43,800	$43,800	0.623	$27,287
8		$0	$43,800	$43,800	0.582	$25,492
9		$0	$43,800	$43,800	0.544	$23,827
10		$0	$78,800	$78,800	0.508	$40,030
11		$0	$43,800	$43,800	0.475	$20,805
12		$0	$43,800	$43,800	0.444	$19,447
13		$0	$43,800	$43,800	0.415	$18,177
14		$0	$43,800	$43,800	0.388	$16,994
15		$0	$78,800	$78,800	0.362	$28,526
16		$0	$43,800	$43,800	0.339	$14,848
17		$0	$43,800	$43,800	0.317	$13,885
18		$0	$43,800	$43,800	0.296	$12,965
19		$0	$43,800	$43,800	0.277	$12,133
20		$0	$78,800	$78,800	0.258	$20,330
21		$0	$43,800	$43,800	0.242	$10,600
22		$0	$43,800	$43,800	0.226	$9,899
23		$0	$43,800	$43,800	0.211	$9,242
24		$0	$43,800	$43,800	0.197	$8,629
25		$0	$78,800	$78,800	0.184	$14,499
26		$0	$43,800	$43,800	0.172	$7,534
27		$0	$43,800	$43,800	0.161	$7,052
28		$0	$43,800	$43,800	0.150	$6,570
29		$0	$43,800	$43,800	0.141	$6,176
30		$0	$78,800	$78,800	0.131	$10,323
					TOTAL PRESENT WORTH	**$8,212,634**

CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 6: Residual Plume Pumping and On-Site Treatment/Recharge
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
1 PROJECT DOCUMENTS/INSTITUTIONAL CONTROLS											
1.1 Prepare Documents & Plans including Permits	500	hr			$40.00		$0	$0	$20,000	$0	$20,000
1.2 Prepare Deed Restrictions	125	hr			$40.00		$0	$0	$5,000	$0	$5,000
2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT											
2.1 Office Trailer (2)	12	mo	$345.00				$4,140	$0	$0	$0	$4,140
2.2 Field Office Support	6	mo		$135.00			$0	$810	$0	$0	$810
2.3 Storage Trailer (1)	6	mo	$85.00				$510	$0	$0	$0	$510
2.4 Construction Survey	1	ls	$18,000.00				$18,000	$0	$0	$0	$18,000
2.5 Equipment Mobilization/Demobilization	8	ea			$45.50	$229.00	$0	$0	$364	$1,832	$2,196
2.6 Install Utilities for Treatment Systems	1	ls	$150,000.00				$150,000	$0	$0	$0	$150,000
2.7 Professional Oversight (5p * 5 days)	26	wk			$4,000.00		$0	$0	$104,000	$0	$104,000
3 DECONTAMINATION											
3.1 Decontamination Trailer (2 for 6 months)	12	mo	$2,275.00				$27,300	$0	$0	$0	$27,300
3.2 Equipment Decon Pad (2 each)	2	ls		$500.00	$450.00	$155.00	$0	$1,000	$900	$310	$2,210
3.3 Decon Water	12,000	gal		$0.20			$0	$2,400	$0	$0	$2,400
3.4 Decon Water Storage Tank, 6,000 gallon (2 for 6 months)	12	mo	$600.00				$7,200	$0	$0	$0	$7,200
3.5 Clean Water Storage Tank, 4,000 gallon (2 for 6 months)	12	mo	$540.00				$6,480	$0	$0	$0	$6,480
3.6 PPE (6 p * 5 days * 26 weeks)	780	day		$30.00			$0	$23,400	$0	$0	$23,400
3.7 Disposal of Decon Waste (liquid & solid)	6	mo	$900.00				$5,400	$0	$0	$0	$5,400
4 PRE-DESIGN INVESTIGATION/TREATMENT STUDIES											
4.1 Pre-Design Investigation/Aquifer Testing	1	ls	$75,000.00				$75,000	$0	$0	$0	$75,000
4.2 Bench-Scale Treatability Studies	1	ls	$75,000.00				$75,000	$0	$0	$0	$75,000
5 GROUNDWATER EXTRACTION SYSTEM MODIFICATION											
5.1 Install Pumping Wells, 4" dia. (5@125', 5@400', level C)	2,625	ft	$35.00				$91,875	$0	$0	$0	$91,875
5.2 Well Development (2 hr/well)	20	hr	$35.00				$700	$0	$0	$0	$700
5.3 21,000 Gallon Steel Tank, Open Top, 2 tanks for 6 month	12	mo		$1,140.00			$0	$13,680	$0	$0	$13,680
5.4 Transport/Dispose IDW Off-site	13	tanker	$2,575.00				$33,475	$0	$0	$0	$33,475
5.5 Extraction Pumps, 4" dia., 0.3-7 gpm, 321-520 head	5	ea	$2,395.00				$11,975	$0	$0	$0	$11,975
5.6 Extraction Pumps, 4" dia., 21-32 gpm, 121-160 head	5	ea	$1,785.00				$8,925	$0	$0	$0	$8,925
5.7 Vault Boxes and Misc. Piping/Valves at Well Head	41	ea		$399.50	$299.63		$0	$16,380	$12,285	$0	$28,664
5.8 Collection Piping/Fittings, 3"/6" PE	200	lf		$5.02	$15.08	$4.40	$0	$1,004	$3,016	$880	$4,900
5.9 Transfer Piping/Fittings, 4"/8" PE	1,000	lf		$8.21	$16.91	$4.93	$0	$8,210	$16,910	$4,930	$30,050
5.10 Transfer Pumps, 50 gpm, 3 HP	1	ea		$496.00	$271.48		$0	$496	$271	$0	$767
5.11 Leak Detection Monitor	1,200	lf		$9.50	$4.75		$0	$11,400	$5,700	$0	$17,100
5.12 Leak Detection Loop	1	ea		$580.00	$1,109.00		$0	$580	$1,109	$0	$1,689
5.13 Install New Sump, 8' by 8' by 10' deep	1	ea		$2,425.00	$1,300.00	$560.00	$0	$2,425	$1,300	$560	$4,285
6 GROUNDWATER TREATMENT SYSTEM											
6.1 Building Foundation	1,000	sf	$3.87				$3,870	$0	$0	$0	$3,870
6.2 Treatment Building	1,000	sf	$11.03				$11,030	$0	$0	$0	$11,030
6.3 Building Misc. (doors/vent/insulation/misc.)	1	ls	$2,500.00				$2,500	$0	$0	$0	$2,500

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 6: Residual Plume Pumping and On-Site Treatment/Recharge
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
6.4 Equalization Tank (1,500 gal)	1	ea		$1,965.00	$724.03	$120.84	$0	$1,965	$724	$121	$2,810
6.5 Top Mounted Mixer (0.75 HP)	1	ea		$2,042.00	$40.00		$0	$2,042	$40	$0	$2,082
6.6 Centrifugal Transfer Pump, 50 gpm (2 HP)	2	ea		$496.00	$271.48		$0	$992	$543	$0	$1,535
6.7 Bag Filter, 50 gpm, dual element, 25 micron	1	ea		$3,500.00	$500.00		$0	$3,500	$500	$0	$4,000
6.8 Air Stripper, 3 ft dia, 45 ft high, packing (7.5 HP blower)	1	ea		$56,000.00	$5,279.00	$881.12	$0	$56,000	$5,279	$881	$62,160
6.9 Centrifugal Transfer Pump, 50 gpm (2.5 HP)	2	ea		$496.00	$271.48		$0	$992	$543	$0	$1,535
6.10 Offgas Heater, 7.5 kW	1	ea		$5,057.00	$577.00		$0	$5,057	$577	$0	$5,634
6.11 GAC, vapor-phase, 13,600 lbs	2	ea		$52,349.00	$506.82	$84.59	$0	$104,698	$1,014	$169	$105,881
6.12 GAC, liquid-phase, 5,000 lbs	2	ea		$31,274.00	$9,492.00	$2,162.00	$0	$62,548	$18,984	$4,324	$85,856
6.13 Instruments and Controls	1	ls		$12,000.00	$700.00		$0	$12,000	$700	$0	$12,700
6.14 Plumb System	1	ls		$14,000.00	$10,000.00		$0	$14,000	$10,000	$0	$24,000
6.15 System Start-Up and Testing	1	ls		$1,000.00	$13,260.00		$0	$1,000	$13,260	$0	$14,260
7 ELECTRICAL COSTS - EXTRACTION AND TREATMENT											
7.1 30 amp Safety Switch, Non-Fused, 600V, NEMA 4 Enclos	12	ea		$705.00	$88.00	$0.00	$0	$8,460	$1,056	$0	$9,516
7.2 Electrical Manholes, 4' x 6' x 7'	4	ea		$1,175.00	$670.00	$280.00	$0	$4,700	$2,680	$1,120	$8,500
7.3 Underground Marking Tape, 6" wide	1300	ft		$0.28	$0.26	$0.00	$0	$364	$338	$0	$702
7.4 2" PVC, Schedule 40 Conduit	15000	ft		$0.97	$1.47	$0.00	$0	$14,550	$22,050	$0	$36,600
7.5 1/C #8, THHN, Copper Conductor, Stranded	493	clf		$15.60	$33.00	$0.00	$0	$7,691	$16,269	$0	$23,960
7.6 1/C #10, THHN, Copper Conductor, Stranded	169	clf		$9.30	$26.50	$0.00	$0	$1,572	$4,479	$0	$6,050
7.7 1/C #12, THHN, Copper Conductor, Stranded	42	clf		$6.05	$24.00	$0.00	$0	$254	$1,008	$0	$1,262
7.8 Trench Excavation, 48"D x 36"W x 1300'L	578	cy		$0.00	$4.04	$4.98	$0	$0	$2,335	$2,878	$5,214
7.9 Trench Bedding, Sand, 6"D	72	cy		$3.50	$3.85	$1.35	$0	$252	$277	$97	$626
7.10 Trench Backfill	505	cy		$0.00	$0.50	$0.49	$0	$0	$253	$247	$500
7.11 3/4" PVC Coated Conduit	240	ft		$3.78	$3.77	$0.00	$0	$907	$905	$0	$1,812
7.12 3/4" PVC Coated Elbows	72	ea		$9.50	$11.00	$0.00	$0	$684	$792	$0	$1,476
7.13 3/4" Conduit Hub	24	ea		$23.50	$16.50	$0.00	$0	$564	$396	$0	$960
7.14 Junction Box 6" x 6" x 6", Nema 4	13	ea		$139.00	$66.00	$0.00	$0	$1,807	$858	$0	$2,665
7.15 3/4" dia, 10' long, Copper Ground Rod	13	ea		29.50	60.00	0.00	$0	$384	$780	$0	$1,164
7.16 Bare Copper Wire, #8 Solid	2	clf		$14.00	$24.00	$0.00	$0	$28	$48	$0	$76
7.17 Ground Clamps, Heavy Duty, Bronze	13	ea		$11.70	$33.00	$0.00	$0	$152	$429	$0	$581
7.18 Heat Trace, Shielded, Self Regulating, 3 W/ft	1.3	clf		$470.00	$43.82	$0.00	$0	$611	$57	$0	$668
7.19 Heat Trace Power Connection Box	13	ea		$78.00	$34.43	$0.00	$0	$1,014	$448	$0	$1,462
7.20 Heat Trace End Seal	13	ea		$20.25	$6.26	$0.00	$0	$263	$81	$0	$345
7.21 Motor Control Center, 7 Vert Sections, 42,000 RMS	9	sect		$1,800.00	$330.00	$0.00	$0	$16,200	$2,970	$0	$19,170
7.22 Copper Bus Bars for Item 1 (Add On)	9	sect		$164.00	$0.00	$0.00	$0	$1,476	$0	$0	$1,476
7.23 NEMA 12 Enclosures (Add On)	9	sect		$94.50	$0.00	$0.00	$0	$851	$0	$0	$851
7.24 Indicating Lights for Starters (Add On)	18	ea		$73.50	$16.50	$0.00	$0	$1,323	$297	$0	$1,620
7.25 Selector Switch for Starters (Add On)	18	ea		$73.50	$16.50	$0.00	$0	$1,323	$297	$0	$1,620
7.31 Transformer, 25KVA	1	ea		$1,175.00	$530.00	$0.00	$0	$1,175	$530	$0	$1,705
7.32 Distribution Panelboard	1	ea		$2,275.00	$1,100.00	$0.00	$0	$2,275	$1,100	$0	$3,375

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 6: Residual Plume Pumping and On-Site Treatment/Recharge
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
7.33 Auxiliary Contacts	128	ea		$201.00	$16.50	$0.00	$0	$25,728	$2,112	$0	$27,840
7.34 3/4" Rigid Steel Conduit, Galvanized	2000	ft		$1.81	$3.30	$0.00	$0	$3,620	$6,600	$0	$10,220
7.35 1" Rigid Steel Conduit, Galvanized	200	ft		$2.53	$4.06	$0.00	$0	$506	$812	$0	$1,318
7.36 4" Rigid Steel Conduit, Galvanized	50	ft		$16.50	$13.20	$0.00	$0	$825	$660	$0	$1,485
7.37 1/C #12 THHN Copper Conductor	200	clf		$6.05	$24.00	$0.00	$0	$1,210	$4,800	$0	$6,010
7.38 1/C #10 THHN Copper Conductor	5	clf		$9.30	$26.50	$0.00	$0	$47	$133	$0	$179
7.39 1/C #8 THHN Copper Conductor	5	clf		$15.60	$33.00	$0.00	$0	$78	$165	$0	$243
7.40 1/C #500 KCMIL Copper Conductor	10	clf		$425.00	$165.00	$0.00	$0	$4,250	$1,650	$0	$5,900
7.41 Treatment Plant Lighting/Distr. System	5000	sf		$2.85	$4.33	$0.00	$0	$14,250	$21,650	$0	$35,900
7.42 30 amp, Safety Switch, 600V, Non-Fused	14	ea		$181.00	$85.00	$0.00	$0	$2,534	$1,190	$0	$3,724
7.43 Treatment Plant Lightning System	1	pkg		$10,000.00	$3,000.00	$0.00	$0	$10,000	$3,000	$0	$13,000
7.44 Treatment Plant Grounding System	1	pkg		$5,000.00	$2,000.00	$0.00	$0	$5,000	$2,000	$0	$7,000
8 GROUNDWATER RECHARGE											
8.1 Injection Well Installation, 20 wells	5,250	ft	$35.00				$183,750	$0	$0	$0	$183,750
8.2 Well Development (2 hr/well)	40	hr	$35.00				$1,400	$0	$0	$0	$1,400
8.3 Recharge Piping,4" PE, buried	1,600	ft		$1.88	$5.45	$2.75	$0	$3,008	$8,720	$4,400	$16,128
Subtotal							$718,530	$486,513	$337,242	$22,750	$1,565,036
Local Area Adjustments							100.0%	100.0%	124.8%	124.8%	
Subtotal							$718,530	$486,513	$420,879	$28,392	$1,654,314
Overhead on Labor Cost @ 30%									$126,264		$126,264
G & A on Labor Cost @ 10%									$42,088		$42,088
G & A on Material Cost @ 10%								$48,651			$48,651
G & A on Subcontract Cost @ 10%							$71,853				$71,853
Total Direct Cost							$790,383	$535,164	$589,230	$28,392	$1,943,170
Indirects on Total Direct Cost @ 30%											$582,951
Profit on Total Direct Cost @ 10%											$194,317
Subtotal											$2,720,438
Health & Safety Monitoring @ 2%											$54,409
Total Field Cost											$2,774,846
Contingency on Total Field Cost @ 20%											$554,969

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 6: Residual Plume Pumping and On-Site Treatment/Recharge
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
Engineering on Total Field Cost @ 10%											$277,485
TOTAL COST											**$3,607,300**

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 6: Residual Plume Pumping and On-Site Treatment/Recharge
Operation and Maintenance Costs per Year

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
YEAR 1						
1	Energy - Electric	263,300	kWh	$0.06	$15,798	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$5,203.54	$5,204	5% of Installation Cost
3	Treatment System & Electrical Maintenance	1	ls	$28,586.30	$28,586	5% of Installation Cost
4	Recharge System Maintenance, Labor & Supplies	1	ls	$10,063.90	$10,064	5% of Installation Cost
5	Changeout/Regeneration of Spent Carbon	353,600	lb.	$3.00	$1,060,800	Replace canister 26 times
6	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
7	*Sample/analysis air stripper offgas from system*	*8*	*ea*	*$350.00*	$2,800	*Two samples per quarter, chlorinated VOCs*
8	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during year 1				$1,142,972	
YEARS 2 AND 3						
1	Energy - Electric	263,300	kWh	$0.06	$15,798	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$5,203.54	$5,204	5% of Installation Cost
3	Treatment System & Electrical Maintenance	1	ls	$28,586.30	$28,586	5% of Installation Cost
4	Recharge System Maintenance, Labor & Supplies	1	ls	$10,063.90	$10,064	5% of Installation Cost
5	Changeout/Regeneration of Spent Carbon	163,200	lb.	$3.00	$489,600	Replace canister 12 times
6	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
7	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
8	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation, years 2 & 3				$571,772	
YEARS 4 THROUGH 8						
1	Energy - Electric	263,300	kWh	$0.06	$15,798	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$5,203.54	$5,204	5% of Installation Cost
3	Treatment System & Electrical Maintenance	1	ls	$28,586.30	$28,586	5% of Installation Cost
4	Recharge System Maintenance, Labor & Supplies	1	ls	$10,063.90	$10,064	5% of Installation Cost
5	Changeout/Regeneration of Spent Carbon	95,200	lb.	$3.00	$285,600	Replace canister 7 times
6	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
7	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
8	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation, years 4 thru 8				$367,772	

CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 6: Residual Plume Pumping and On-Site Treatment/Recharge
Operation and Maintenance Costs per Year

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
	YEARS 9 THROUGH 15					
1	Energy - Electric	263,300	kWh	$0.06	$15,798	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$5,203.54	$5,204	5% of Installation Cost
3	Treatment System & Electrical Maintenance	1	ls	$28,586.30	$28,586	5% of Installation Cost
4	Recharge System Maintenance, Labor & Supplies	1	ls	$9,141.34	$9,141	5% of Installation Cost
5	Changeout/Regeneration of Spent Carbon	40,800	lb.	$3.00	$122,400	Replace canister 3 times
6	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
7	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
8	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation, years 9 thru 15				$203,649	
	YEARS 16 THROUGH 30					
1	Energy - Electric	263,300	kWh	$0.06	$15,798	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$5,203.54	$5,204	5% of Installation Cost
3	Treatment System & Electrical Maintenance	1	ls	$28,586.30	$28,586	5% of Installation Cost
4	Recharge System Maintenance, Labor & Supplies	1	ls	$10,063.90	$10,064	5% of Installation Cost
5	Changeout/Regeneration of Spent Carbon	27,200	lb.	$3.00	$81,600	Replace canister 2 times
6	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
7	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
8	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation, years 16 thru 30				$163,772	

CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 6: Residual Plume Pumping and On-Site Treatment/Recharge
Annual Sampling Cost

Item	Cost per Sampling Round Years 1 thru 30*	Item Cost per 5 Years	Notes
Sampling	$11,400		Collect groundwater samples, per sampling period (twice per year with local labor)
Analysis/Water	$6,500		Water samples, per sampling period, (including lab and in-house QA) for TCL VOC's and TAL metals. Monitoring from 20 locations for 30 years.
Report	$4,000		Obtain lab, prepare sampling plan, document sampling events and results
Maintenance		$15,000	Extraction well inspection, cleaning, antifouling, and maintenance
Site Review	$0	$10,000	Review of documents and data evaluation/recommendations; preparation of summary reports for 5-year CERCLA reviews
TOTALS	$21,900	$25,000	

* Semi-annually years 1 through 30

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 6: Residual Plume Pumping and On-Site Treatment/Recharge
Present Worth Analysis

Year	Capital Cost	Operation and Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$3,607,300			$3,607,300	1.000	$3,607,300
1		$1,142,972	$43,800	$1,186,772	0.935	$1,109,632
2		$571,772	$43,800	$615,572	0.873	$537,394
3		$571,772	$43,800	$615,572	0.816	$502,307
4		$367,772	$43,800	$411,572	0.763	$314,029
5		$367,772	$68,800	$436,572	0.713	$311,276
6		$367,772	$43,800	$411,572	0.666	$274,107
7		$367,772	$43,800	$411,572	0.623	$256,409
8		$367,772	$43,800	$411,572	0.582	$239,535
9		$203,649	$43,800	$247,449	0.544	$134,612
10		$203,649	$68,800	$272,449	0.508	$138,404
11		$203,649	$43,800	$247,449	0.475	$117,538
12		$203,649	$43,800	$247,449	0.444	$109,867
13		$203,649	$43,800	$247,449	0.415	$102,691
14		$203,649	$43,800	$247,449	0.388	$96,010
15		$203,649	$68,800	$272,449	0.362	$98,627
16		$163,772	$43,800	$207,572	0.339	$70,367
17		$163,772	$43,800	$207,572	0.317	$65,800
18		$163,772	$43,800	$207,572	0.296	$61,441
19		$163,772	$43,800	$207,572	0.277	$57,497
20		$163,772	$68,800	$232,572	0.258	$60,004
21		$163,772	$43,800	$207,572	0.242	$50,232
22		$163,772	$43,800	$207,572	0.226	$46,911
23		$163,772	$43,800	$207,572	0.211	$43,798
24		$163,772	$43,800	$207,572	0.197	$40,892
25		$163,772	$68,800	$232,572	0.184	$42,793
26		$163,772	$43,800	$207,572	0.172	$35,702
27		$163,772	$43,800	$207,572	0.161	$33,419
28		$163,772	$43,800	$207,572	0.150	$31,136
29		$163,772	$43,800	$207,572	0.141	$29,268
30		$163,772	$68,800	$232,572	0.131	$30,467
					TOTAL PRESENT WORTH	**$8,649,466**

CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 7: Groundwater Containment of Valley Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Capital Cost

Item	Quantity	Unit	Unit Cost				Total Cost				Total Direct Cost
			Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	
1 PROJECT DOCUMENTS/INSTITUTIONAL CONTROLS											
1.1 Prepare Documents & Plans including Permits	500	hr			$40.00		$0	$0	$20,000	$0	$20,000
1.2 Prepare Deed Restrictions/Obtain Site Access	500	hr			$40.00		$0	$0	$20,000	$0	$20,000
2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT											
2.1 Office Trailer (2)	12	mo	$345.00				$4,140	$0	$0	$0	$4,140
2.2 Field Office Support	6	mo		$135.00			$0	$810	$0	$0	$810
2.3 Storage Trailer (1)	6	mo	$85.00				$510	$0	$0	$0	$510
2.4 Construction Survey	1	ls	$18,000.00				$18,000	$0	$0	$0	$18,000
2.5 Equipment Mobilization/Demobilization	8	ea			$45.50	$229.00	$0	$0	$364	$1,832	$2,196
2.6 Install Utilities for Treatment Systems	1	ls	$150,000.00				$150,000	$0	$0	$0	$150,000
2.7 Professional Oversight (5p * 5 days)	26	wk			$4,000.00		$0	$0	$104,000	$0	$104,000
3 DECONTAMINATION											
3.1 Decontamination Trailer (2 for 6 months)	12	mo	$2,275.00				$27,300	$0	$0	$0	$27,300
3.2 Equipment Decon Pad (2 each)	2	ls		$500.00	$450.00	$155.00	$0	$1,000	$900	$310	$2,210
3.3 Decon Water	12,000	gal		$0.20			$0	$2,400	$0	$0	$2,400
3.4 Decon Water Storage Tank, 6,000 gallon (2 for 6 mo)	12	mo	$600.00				$7,200	$0	$0	$0	$7,200
3.5 Clean Water Storage Tank, 4,000 gallon (2 for 6 mo)	12	mo	$540.00				$6,480	$0	$0	$0	$6,480
3.6 PPE (6 p * 5 days * 26 weeks)	780	day		$30.00			$0	$23,400	$0	$0	$23,400
3.7 Disposal of Decon Waste (liquid & solid)	6	mo	$900.00				$5,400	$0	$0	$0	$5,400
4 PRE-DESIGN INVESTIGATION/TREATMENT STUDIES											
4.1 Pre-Design Investigation/Aquifer Testing	1	ls	$290,000.00				$290,000	$0	$0	$0	$290,000
4.2 Groundwater Modeling/Fate and Transport Analysis	1	ls	$62,800.00				$62,800	$0	$0	$0	$62,800
4.3 Bench-Scale Treatability Studies	1	ls	$75,000.00				$75,000	$0	$0	$0	$75,000
5 GROUNDWATER EXTRACTION SYSTEM MODIFICATION											
5.1 Install Pumping Wells, (22 @ 400')	8,800	ft	$35.00				$308,000	$0	$0	$0	$308,000
5.2 Well Development (2 hr/well)	44	hr	$35.00				$1,540	$0	$0	$0	$1,540
5.3 21,000 Gallon Steel Tank, Open Top, 3 tanks/6 mo	18	mo		$1,140.00			$0	$20,520	$0	$0	$20,520
5.4 Transport/Dispose IDW Off-site	33	tanker	$2,575.00				$84,975	$0	$0	$0	$84,975
5.5 Extraction Pumps, 4" dia., 0.3-7 gpm, 321-520 head	22	ea	$2,395.00				$52,690	$0	$0	$0	$52,690
5.6 Vault Boxes and Misc. Piping/Valves at Well Head	22	ea		$399.50	$299.63		$0	$8,789	$6,592	$0	$15,381
5.7 Collection Piping/Fittings, 16"/24" PE	1,600	lf		$57.81	$38.95	$11.38	$0	$92,496	$62,320	$18,208	$173,024
5.8 Transfer Piping/Fittings, 16"/24" PE	400	lf		$57.81	$38.95	$11.38	$0	$23,124	$15,580	$4,552	$43,256
5.9 Transfer Pumps, 120 gpm, 5 HP	2	ea		$3,999.00	$1,552.00		$0	$7,998	$3,104	$0	$11,102
5.10 Transfer Pumps, 190 gpm, 10 HP		ea		$3,587.00	$998.15		$0	$0	$0	$0	$0
5.11 Leak Detection Monitor	2,000	lf		$9.50	$4.75		$0	$19,000	$9,500	$0	$28,500
5.12 Leak Detection Loop	2	ea		$580.00	$1,109.00		$0	$1,160	$2,218	$0	$3,378
5.13 Highway Boring	80	lf	$305.00				$24,400	$0	$0	$0	$24,400
5.14 Boring Preparation (pits, mob/demob)	1	ls	$6,000.00				$6,000	$0	$0	$0	$6,000

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 7: Groundwater Containment of Valley Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Capital Cost

			Unit Cost				Total Cost				Total Direct
Item	Quantity	Unit	Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	Cost
5.15 Install New Sump, 8' by 8' by 10' deep	1	ea		$2,425.00	$1,300.00	$560.00	$0	$2,425	$1,300	$560	$4,285
6 GROUNDWATER TREATMENT SYSTEM											
6.1 Building Foundation	2,000	sf	$3.87				$7,740	$0	$0	$0	$7,740
6.2 Treatment Building	2,000	sf	$11.03				$22,060	$0	$0	$0	$22,060
6.3 Building Misc. (doors/vent/insulation/misc.)	2	ls	$1,500.00				$3,000	$0	$0	$0	$3,000
6.4 Equalization Tank (7,500 gal)	2	ea		$6,483.00	$1,056.00	$176.00	$0	$12,966	$2,112	$352	$15,430
6.5 Top Mounted Mixer (5 HP)	2	ea		$22,113.00	$1,215.00		$0	$44,226	$2,430	$0	$46,656
6.6 Centrifugal Transfer Pump, 250 gpm (10 HP)	4	ea		$2,385.00	$390.00		$0	$9,540	$1,560	$0	$11,100
6.7 GAC, liquid-phase, 10,000 lbs	4	ea		$58,000.00	$8,890.00	$2,941.00	$0	$232,000	$35,560	$11,764	$279,324
6.8 Instruments and Controls	2	ls		$5,000.00	$700.00		$0	$10,000	$1,400	$0	$11,400
6.9 Plumb System	2	ls		$3,000.00	$2,000.00		$0	$6,000	$4,000	$0	$10,000
6.10 System Start-Up and Testing	2	ls		$1,000.00	$7,000.00		$0	$2,000	$14,000	$0	$16,000
7 ELECTRICAL COSTS - EXTRACTION AND TREATMENT											
7.1 30 amp Safety Switch, Non-Fused, 600V, NEMA 4 Enc	26	ea		$705.00	$88.00	$0.00	$0	$18,330	$2,288	$0	$20,618
7.2 Electrical Manholes, 4' x 6' x 7'	6	ea		$1,175.00	$670.00	$280.00	$0	$7,050	$4,020	$1,680	$12,750
7.3 Underground Marking Tape, 6" wide	2000	ft		$0.28	$0.26	$0.00	$0	$560	$520	$0	$1,080
7.4 2" PVC, *Schedule 40 Conduit*	20000	ft		$0.97	$1.47	$0.00	$0	$19,400	$29,400	$0	$48,800
7.5 1/C #8, THHN, Copper Conductor, Stranded	480	clf		$15.60	$33.00	$0.00	$0	$7,488	$15,840	$0	$23,328
7.6 1/C #10, THHN, Copper Conductor, Stranded	360	clf		$9.30	$26.50	$0.00	$0	$3,348	$9,540	$0	$12,888
7.7 1/C #12, THHN, Copper Conductor, Stranded	24	clf		$6.05	$24.00	$0.00	$0	$145	$576	$0	$721
7.8 Trench Excavation, 48"D x 36"W x 2000'L	778	cy		$0.00	$4.04	$4.98	$0	$0	$3,143	$3,874	$7,018
7.9 Trench Bedding, Sand, 6"D	111	cy		$3.50	$3.85	$1.35	$0	$389	$427	$150	$966
7.10 Trench Backfill	889	cy		$0.00	$0.50	$0.49	$0	$0	$445	$436	$880
7.11 3/4" PVC Coated Conduit	520	ft		$3.78	$3.77	$0.00	$0	$1,966	$1,960	$0	$3,926
7.12 3/4" PVC Coated Elbows	156	ea		$9.50	$11.00	$0.00	$0	$1,482	$1,716	$0	$3,198
7.13 3/4" Conduit Hub	52	ea		$23.50	$16.50	$0.00	$0	$1,222	$858	$0	$2,080
7.14 Junction Box 6" x 6" x 6", Nema 4	26	ea		$139.00	$66.00	$0.00	$0	$3,614	$1,716	$0	$5,330
7.15 3/4" dia, 10' long, Copper Ground Rod	24	ea		29.50	60.00	0.00	$0	$708	$1,440	$0	$2,148
7.16 Bare Copper Wire, #8 Solid	5	clf		$14.00	$24.00	$0.00	$0	$70	$120	$0	$190
7.17 Ground Clamps, Heavy Duty, Bronze	24	ea		$11.70	$33.00	$0.00	$0	$281	$792	$0	$1,073
7.18 Heat Trace, Shielded, Self Regulating, 3 W/ft	3	clf		$470.00	$43.82	$0.00	$0	$1,410	$131	$0	$1,541
7.19 Heat Trace Power Connection Box	26	ea		$78.00	$34.43	$0.00	$0	$2,028	$895	$0	$2,923
7.20 Heat Trace End Seal	26	ea		$20.25	$6.26	$0.00	$0	$527	$163	$0	$689
7.21 Motor Control Center, 6 Vert Sect, 42,000 RMS	6	sect		$1,800.00	$330.00	$0.00	$0	$10,800	$1,980	$0	$12,780
7.22 Copper Bus Bars for Item 1 (Add On)	6	sect		$164.00	$0.00	$0.00	$0	$984	$0	$0	$984
7.23 NEMA 12 Enclosures (Add On)	6	sect		$94.50	$0.00	$0.00	$0	$567	$0	$0	$567
7.24 Indicating Lights for Starters (Add On)	20	ea		$73.50	$16.50	$0.00	$0	$1,470	$330	$0	$1,800
7.25 Selector Switch for Starters (Add On)	20	ea		$73.50	$16.50	$0.00	$0	$1,470	$330	$0	$1,800

CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 7: Groundwater Containment of Valley Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Capital Cost

Item	Quantity	Unit	Unit Cost				Total Cost				Total Direct
			Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	Cost
7.26 Transformer, 25KVA	1	ea		$1,175.00	$530.00	$0.00	$0	$1,175	$530	$0	$1,705
7.27 Distribution Panelboard	1	ea		$2,275.00	$1,100.00	$0.00	$0	$2,275	$1,100	$0	$3,375
7.28 Auxiliary Contacts	40	ea		$201.00	$16.50	$0.00	$0	$8,040	$660	$0	$8,700
7.29 Motor Control Center, 6 Vert Sections, 42,000 RMS	6	sect		$1,800.00	$330.00	$0.00	$0	$10,800	$1,980	$0	$12,780
7.30 Copper Bus Bars for Item 1 (Add On)	6	sect		$164.00	$0.00	$0.00	$0	$984	$0	$0	$984
7.31 NEMA 12 Enclosures (Add On)	6	sect		$94.50	$0.00	$0.00	$0	$567	$0	$0	$567
7.32 Indicating Lights for Starters (Add On)	20	ea		$73.50	$16.50	$0.00	$0	$1,470	$330	$0	$1,800
7.33 Selector Switch for Starters (Add On)	20	ea		$73.50	$16.50	$0.00	$0	$1,470	$330	$0	$1,800
7.34 Transformer, 25KVA	1	ea		$1,175.00	$530.00	$0.00	$0	$1,175	$530	$0	$1,705
7.35 Distribution Panelboard	1	ea		$2,275.00	$1,100.00	$0.00	$0	$2,275	$1,100	$0	$3,375
7.36 Auxiliary Contacts	40	ea		$201.00	$16.50	$0.00	$0	$8,040	$660	$0	$8,700
7.37 3/4" Rigid Steel Conduit, Galvanized	1500	ft		$1.81	$3.30	$0.00	$0	$2,715	$4,950	$0	$7,665
7.38 1" Rigid Steel Conduit, Galvanized	400	ft		$2.53	$4.06	$0.00	$0	$1,012	$1,624	$0	$2,636
7.39 4" Rigid Steel Conduit, Galvanized	100	ft		$16.50	$13.20	$0.00	$0	$1,650	$1,320	$0	$2,970
7.40 1/C #12 THHN Copper Conductor	180	clf		$6.05	$24.00	$0.00	$0	$1,089	$4,320	$0	$5,409
7.41 1/C #10 THHN Copper Conductor	5	clf		$9.30	$26.50	$0.00	$0	$47	$133	$0	$179
7.42 1/C #8 THHN Copper Conductor	5	clf		$15.60	$33.00	$0.00	$0	$78	$165	$0	$243
7.43 1/C #500 KCMIL Copper Conductor	20	clf		$425.00	$165.00	$0.00	$0	$8,500	$3,300	$0	$11,800
7.44 Treatment Plant Lighting/Distr. System	2000	sf		$2.85	$4.33	$0.00	$0	$5,700	$8,660	$0	$14,360
7.45 30 amp. Safety Switch, 600V, Non-Fused	14	ea		$181.00	$85.00	$0.00	$0	$2,534	$1,190	$0	$3,724
7.46 Treatment Plant Lightning System	2	pkg		$10,000.00	$3,000.00	$0.00	$0	$20,000	$6,000	$0	$26,000
7.47 Treatment Plant Grounding System	2	pkg		$5,000.00	$2,000.00	$0.00	$0	$10,000	$4,000	$0	$14,000
8 GROUNDWATER DISCHARGE TO WEST BRANCH											
8.1 Discharge Piping, 16" PE	400	ft		$17.14	$11.35	$6.24	$0	$6,856	$4,540	$2,496	$13,892
8.2 Pumps - 250 GPM, 15 HP	2	ea		$3,889.00	$354.77		$0	$7,778	$710	$0	$8,488
8.3 Outfall Structures (Headwall)	2	ea		$440.00	$1,100.00	$375.00	$0	$880	$2,200	$750	$3,830
9 SITE RESTORATION											
9.1 Top Dress Soil	1,667	sy		$2.91	$1.53		$0	$4,851	$2,551	$0	$7,401
9.2 Fine Grading & Seeding	1,667	sy		$0.29	$1.13	$0.20	$0	$483	$1,884	$333	$2,701
9.3 Pavement Repair/Replacement	10	sy		$6.05	$16.10	$1.91	$0	$61	$161	$19	$241
Subtotal							$1,157,235	$717,666	$440,497	$47,316	$2,362,714
Local Area Adjustments							100.0%	100.0%	124.8%	124.8%	
Subtotal							$1,157,235	$717,666	$549,740	$59,051	$2,483,692
Overhead on Labor Cost @ 30%									$164,922		$164,922

CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 7: Groundwater Containment of Valley Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Capital Cost

			Unit Cost				Total Cost				Total Direct
Item	Quantity	Unit	Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	Cost
G & A on Labor Cost @ 10%									$54,974		$54,974
G & A on Material Cost @ 10%								$71,767			$71,767
G & A on Subcontract Cost @ 10%							$115,724				$115,724
Total Direct Cost							$1,272,959	$789,433	$769,636	$59,051	$2,891,078
Indirects on Total Direct Cost @ 30%											$867,323
Profit on Total Direct Cost @ 10%											$289,108
Subtotal											$4,047,509
Health & Safety Monitoring @ 2%											$80,950
Total Field Cost											$4,128,460
Contingency on Total Field Cost @ 20%											$825,692
Engineering on Total Field Cost @ 10%											$412,846
TOTAL COST											**$5,366,997**

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 7: Groundwater Containment of Valley Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Operation and Maintenance Costs per Year

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
YEARS 1, 3 THROUGH 9, AND 11 THROUGH 30						
1	Energy - Electric	1,872,500	kWh	$0.06	$112,350	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,366.54	$16,367	5% of Installation Cost
3	Treatment System & Electrical Maintenance	1	ls	$34,873.26	$34,873	5% of Installation Cost
4	Discharge System Maintenance, Labor & Supplies	1	ls	$1,310.48	$1,310	5% of Installation Cost
5	Sample/analysis influent/effluent from system	48	ea	$90.00	$4,320	Two samples per system per month, chlorinated VOCs
6	Quarterly Reports	8	ea	$4,000.00	$32,000	
	Subtotal Cost for One Year of Operation				$201,220	
YEARS 2 AND 10						
1	Energy - Electric	1,872,500	kWh	$0.06	$112,350	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,366.54	$16,367	5% of Installation Cost
3	Treatment System & Electrical Maintenance	1	ls	$34,873.26	$34,873	5% of Installation Cost
4	Discharge System Maintenance, Labor & Supplies	1	ls	$1,310.48	$1,310	5% of Installation Cost
5	Changeout/Regeneration of Spent Carbon	40,000	lb.	$3.00	$120,000	Replace canister, 2 per system, 10,000 lb each
6	Sample/analysis influent/effluent from system	48	ea	$90.00	$4,320	Two samples per system per month, chlorinated VOCs
7	Quarterly Reports	8	ea	$4,000.00	$32,000	
	Subtotal Cost for One Year of Operation				$321,220	

CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 7: Groundwater Containment of Valley Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Annual Sampling Cost

Item	Cost per Sampling Round Years 1 thru 30*	Item Cost per 5 Years	Notes
Sampling	$11,400		Collect groundwater samples, per sampling period (twice per year with local labor)
Analysis/Water	$6,500		Water samples, per sampling period, (including lab and in-house QA) for TCL VOC's and TAL metals. Monitoring from 20 locations for 30 years.
Report	$4,000		Obtain lab, prepare sampling plan, document sampling events and results
Maintenance		$15,000	Extraction well inspection, cleaning, antifouling, and maintenance
Site Review		$10,000	Review of documents and data evaluation/recommendations; preparation of summary reports for 5-year CERCLA reviews
TOTALS	$21,900	$25,000	

* Semi-annually years 1 through 30

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 7: Groundwater Containment of Valley Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Present Worth Analysis

Year	Capital Cost	Operation and Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$5,366,997			$5,366,997	1.000	$5,366,997
1		$201,220	$43,800	$245,020	0.935	$229,094
2		$321,220	$43,800	$365,020	0.873	$318,663
3		$201,220	$43,800	$245,020	0.816	$199,937
4		$201,220	$43,800	$245,020	0.763	$186,950
5		$201,220	$68,800	$270,020	0.713	$192,524
6		$201,220	$43,800	$245,020	0.666	$163,184
7		$201,220	$43,800	$245,020	0.623	$152,648
8		$201,220	$43,800	$245,020	0.582	$142,602
9		$201,220	$43,800	$245,020	0.544	$133,291
10		$321,220	$68,800	$390,020	0.508	$198,130
11		$201,220	$43,800	$245,020	0.475	$116,385
12		$201,220	$43,800	$245,020	0.444	$108,789
13		$201,220	$43,800	$245,020	0.415	$101,683
14		$201,220	$43,800	$245,020	0.388	$95,068
15		$201,220	$68,800	$270,020	0.362	$97,747
16		$201,220	$43,800	$245,020	0.339	$83,062
17		$201,220	$43,800	$245,020	0.317	$77,671
18		$201,220	$43,800	$245,020	0.296	$72,526
19		$201,220	$43,800	$245,020	0.277	$67,871
20		$201,220	$68,800	$270,020	0.258	$69,665
21		$201,220	$43,800	$245,020	0.242	$59,295
22		$201,220	$43,800	$245,020	0.226	$55,375
23		$201,220	$43,800	$245,020	0.211	$51,699
24		$201,220	$43,800	$245,020	0.197	$48,269
25		$201,220	$68,800	$270,020	0.184	$49,684
26		$201,220	$43,800	$245,020	0.172	$42,143
27		$201,220	$43,800	$245,020	0.161	$39,448
28		$201,220	$43,800	$245,020	0.150	$36,753
29		$201,220	$43,800	$245,020	0.141	$34,548
30		$201,220	$68,800	$270,020	0.131	$35,373
					TOTAL PRESENT WORTH	**$8,627,074**

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 8: In-Situ Treatment of the Valley Plume, Institutional Controls, and Monitoring
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
1 PROJECT DOCUMENTS/INSTITUTIONAL CONTROLS											
1.1 *Prepare Documents & Plans including Permits*	200	hr			$40.00		$0	$0	$8,000	$0	$8,000
1.2 Prepare Deed Restrictions	150	hr			$40.00		$0	$0	$6,000	$0	$6,000
2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT											
2.1 Office Trailer (2)	12	mo	$345.00				$4,140	$0	$0	$0	$4,140
2.2 Field Office Support	6	mo		$135.00			$0	$810	$0	$0	$810
2.3 *Storage Trailer (1)*	6	mo	$85.00				$510	$0	$0	$0	$510
2.4 Construction Survey	1	ls	$1,000.00				$1,000	$0	$0	$0	$1,000
2.5 Equipment Mobilization/Demobilization	5	ea			$45.50	$229.00	$0	$0	$228	$1,145	$1,373
2.6 Site Utilities Installation	1	ls	$150,000.00				$150,000	$0	$0	$0	$150,000
2.7 Site Utilities	6	mo	$1,000.00				$6,000	$0	$0	$0	$6,000
2.8 *Professional Oversight (5p * 5 days)*	26	wk			$4,000.00		$0	$0	$104,000	$0	$104,000
3 DECONTAMINATION											
3.1 Decontamination Trailer	6	mo	$2,275.00				$13,650	$0	$0	$0	$13,650
3.2 Equipment Decon Pad	1	ls		$500.00	$450.00	$155.00	$0	$500	$450	$155	$1,105
3.3 Decon Water	6,000	gal		$0.20			$0	$1,200	$0	$0	$1,200
3.4 Decon Water Storage Tank, 6,000 gallon	6	mo	$600.00				$3,600	$0	$0	$0	$3,600
3.5 Clean Water Storage Tank, 4,000 gallon	6	mo	$540.00				$3,240	$0	$0	$0	$3,240
3.6 PPE (6 p * 5 days * 26 weeks)	780	day		$30.00			$0	$23,400	$0	$0	$23,400
3.7 Pre-Disposal of Decon Waste (liquid & solid)	6	mo	$900.00				$5,400	$0	$0	$0	$5,400
4 PRE-DESIGN INVESTIGATION											
4.1 Pre-Design Investigation/Aquifer Testing	1	ls	$290,000.00				$290,000	$0	$0	$0	$290,000
4.2 Groundwater Modeling/Fate & Transport Analysis	1	ls	$62,800.00				$62,800	$0	$0	$0	$62,800
5 TREATMENT STUDY											
5.1 Bench Test	1	ea	$3,500.00				$3,500	$0	$0	$0	$3,500
5.2 Develop Work Plan	1	ls	$7,500.00				$7,500	$0	$0	$0	$7,500
5.3 Technical Report	1	ls	$7,500.00				$7,500	$0	$0	$0	$7,500
5.4 Stainless Steel Application Wells, 2-in, 2@80'	160	ft	$70.00				$11,200	$0	$0	$0	$11,200
5.5 Stainless Steel Application Wells, 2-in, 2@300'	600	ft	$70.00				$42,000	$0	$0	$0	$42,000
5.6 Two-Cycle Pilot Test	1	ls	$83,750.00				$83,750	$0	$0	$0	$83,750
6 IN-SITU OXIDATION (CLEANOX®)											
6.1 Install Application Wells (100 @ 150' - 400')	25,000	ea	$70.00				$1,750,000	$0	$0	$0	$1,750,000
6.2 Well Development (2 hr/well)	200	hr	$35.00				$7,000	$0	$0	$0	$7,000
6.3 21,000 Gallon Steel Tank, Open Top, 3 tanks for 3 montl	9	mo		$1,140.00			$0	$10,260	$0	$0	$10,260
6.4 Transport/Dispose IDW Off-site	150	tanker	$2,575.00				$386,250	$0	$0	$0	$386,250
6.5 CleanOX® Treatment	1	ls	$1,250,000.00				$1,250,000	$0	$0	$0	$1,250,000
7 SAMPLING AND ANALYSIS OF TREATMENT MONITORING WELLS											
7.1 Install Monitoring Wells (12 @ 400 ft)	4,800	ft	$35.00				$168,000	$0	$0	$0	$168,000
7.2 Well Development (2 hr/well)	24	hr	$35.00				$840	$0	$0	$0	$840
7.3 Well Sampling, 12 wells per month for 6 months	6	ea	$8,400.00				$50,400	$0	$0	$0	$50,400

CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 8: In-Situ Treatment of the Valley Plume, Institutional Controls, and Monitoring
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
7.4 Analysis, TCL VOCs and TAL metals, 12 wells/6 months	72	ea	$325.00				$23,400	$0	$0	$0	$23,400
8 SITE RESTORATION											
8.1 Top Dress Soil	1,667	sy		$2.91	$1.53		$0	$4,851	$2,551	$0	$7,401
8.2 Fine Grading & Seeding	1,667	sy		$0.29	$1.13	$0.20	$0	$483	$1,884	$333	$2,701
Subtotal							$4,331,680	$41,504	$123,112	$1,633	$4,497,930
Local Area Adjustments							100.0%	100.0%	124.8%	124.8%	
Subtotal							$4,331,680	$41,504	$153,643	$2,038	$4,528,866
Overhead on Labor Cost @ 30%									$46,093		$46,093
G & A on Labor Cost @ 10%									$15,364		$15,364
G & A on Material Cost @ 10%								$4,150			$4,150
G & A on Subcontract Cost @ 10%							$433,168				$433,168
Total Direct Cost							$4,764,848	$45,655	$215,101	$2,038	$5,027,642
Indirects on Total Direct Cost @ 15%											$754,146
Profit on Total Direct Cost @ 10%											$502,764
Subtotal											$6,284,553
Health & Safety Monitoring @ 2%											$125,691
Total Field Cost											$6,410,244
Contingency on Total Field Cost @ 20%											$1,282,049
Engineering on Total Field Cost @ 5%											$320,512
TOTAL COST											**$8,012,805**

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 8: In-Situ Treatment of the Valley Plume, Institutional Controls, and Monitoring
Annual Sampling Cost

Item	Treatment	Cost per Sampling Round Years 1 thru 30*	Item Cost per 5 Years	Notes
Treatment, Subcontractor	$1,250,000			Annual cost for quarterly treatment
Treatment, Oversight	$187,500			15% of subcontractor cost
Sampling		$11,400		Collect groundwater samples, per sampling period (twice per year with local labor)
Analysis/Water		$6,500		Water samples, per sampling period, (including lab and in-house QA) for TCL VOC's and TAL metals. Monitoring from 20 locations for 30 years.
Report		$4,000		Obtain lab, prepare sampling plan, document sampling events and results
Maintenance			$15,000	Injection well inspection, cleaning, antifouling, and maintenance
Site Review			$20,000	Review of documents and data evaluation/recommendations; preparation of summary reports for 5-year CERCLA reviews
TOTALS	$1,437,500	$21,900	$35,000	

* Twice per year

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 8: In-Situ Treatment of the Valley Plume, Institutional Controls, and Monitoring
Present Worth Analysis

Year	Capital Cost	Operation and Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$8,012,805			$8,012,805	1.000	$8,012,805
1		$0	$1,481,300	$1,481,300	0.935	$1,385,016
2		$0	$1,481,300	$1,481,300	0.873	$1,293,175
3		$0	$1,481,300	$1,481,300	0.816	$1,208,741
4		$0	$1,481,300	$1,481,300	0.763	$1,130,232
5		$0	$1,516,300	$1,516,300	0.713	$1,081,122
6		$0	$1,481,300	$1,481,300	0.666	$986,546
7		$0	$1,481,300	$1,481,300	0.623	$922,850
8		$0	$1,481,300	$1,481,300	0.582	$862,117
9		$0	$1,481,300	$1,481,300	0.544	$805,827
10		$0	$1,516,300	$1,516,300	0.508	$770,280
11		$0	$1,481,300	$1,481,300	0.475	$703,618
12		$0	$1,481,300	$1,481,300	0.444	$657,697
13		$0	$1,481,300	$1,481,300	0.415	$614,740
14		$0	$1,481,300	$1,481,300	0.388	$574,744
15		$0	$1,516,300	$1,516,300	0.362	$548,901
16		$0	$1,481,300	$1,481,300	0.339	$502,161
17		$0	$1,481,300	$1,481,300	0.317	$469,572
18		$0	$1,481,300	$1,481,300	0.296	$438,465
19		$0	$1,481,300	$1,481,300	0.277	$410,320
20		$0	$1,516,300	$1,516,300	0.258	$391,205
21		$0	$1,481,300	$1,481,300	0.242	$358,475
22		$0	$1,481,300	$1,481,300	0.226	$334,774
23		$0	$1,481,300	$1,481,300	0.211	$312,554
24		$0	$1,481,300	$1,481,300	0.197	$291,816
25		$0	$1,516,300	$1,516,300	0.184	$278,999
26		$0	$1,481,300	$1,481,300	0.172	$254,784
27		$0	$1,481,300	$1,481,300	0.161	$238,489
28		$0	$1,481,300	$1,481,300	0.150	$222,195
29		$0	$1,481,300	$1,481,300	0.141	$208,863
30		$0	$1,516,300	$1,516,300	0.131	$198,635
					TOTAL PRESENT WORTH	**$26,469,716**

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 9: Groundwater Containment of Center of Plume and Valley Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
1 PROJECT DOCUMENTS/INSTITUTIONAL CONTROLS											
1.1 Prepare Documents & Plans including Permits	1,000	hr			$40.00		$0	$0	$40,000	$0	$40,000
1.2 Prepare Deed Restrictions	625	hr			$40.00		$0	$0	$25,000	$0	$25,000
2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT											
2.1 Office Trailer (2)	12	mo	$345.00				$4,140	$0	$0	$0	$4,140
2.2 Field Office Support	6	mo		$135.00			$0	$810	$0	$0	$810
2.3 Storage Trailer (1)	6	mo	$85.00				$510	$0	$0	$0	$510
2.4 Construction Survey	1	ls	$18,000.00				$18,000	$0	$0	$0	$18,000
2.5 *Equipment Mobilization/Demobilization*	12	ea			$45.50	$229.00	$0	$0	$546	$2,748	$3,294
2.6 Install Utilities for Treatment Systems	1	ls	$150,000.00				$150,000	$0	$0	$0	$150,000
2.7 Professional Oversight (5p * 5 days)	26	wk			$4,000.00		$0	$0	$104,000	$0	$104,000
3 DECONTAMINATION											
3.1 Decontamination Trailer (2 for 6 months)	12	mo	$2,275.00				$27,300	$0	$0	$0	$27,300
3.2 Equipment Decon Pad (2 each)	2	ls		$500.00	$450.00	$155.00	$0	$1,000	$900	$310	$2,210
3.3 Decon Water	12,000	gal		$0.20			$0	$2,400	$0	$0	$2,400
3.4 Decon Water Storage Tank, 6,000 gallon (2 for 6 months	12	mo	$600.00				$7,200	$0	$0	$0	$7,200
3.5 Clean Water Storage Tank, 4,000 gallon (2 for 6 months)	12	mo	$540.00				$6,480	$0	$0	$0	$6,480
3.6 PPE (6 p * 5 days * 26 weeks)	780	day		$30.00			$0	$23,400	$0	$0	$23,400
3.7 Disposal of Decon Waste (liquid & solid)	6	mo	$900.00				$5,400	$0	$0	$0	$5,400
4 PRE-DESIGN INVESTIGATION/TREATMENT STUDIES											
4.1 Pre-Design Investigation/Aquifer Testing	1	ls	$350,000.00				$350,000	$0	$0	$0	$350,000
4.2 *Groundwater Modeling/Fate and Transport Analysis*	1	*ls*	$62,800.00				$62,800	$0	$0	$0	$62,800
4.3 Bench-Scale Treatability Studies	1	ls	$75,000.00				$75,000	$0	$0	$0	$75,000
5 GROUNDWATER EXTRACTION SYSTEM MODIFICATION - CENTER OF PLUME											
5.1 Install Pumping Wells, 4" dia. (41 wells, level C)	9,550	ft	$35.00				$334,250	$0	$0	$0	$334,250
5.2 Well Development (2 hr/well)	82	hr	$35.00				$2,870	$0	$0	$0	$2,870
5.3 21,000 Gallon Steel Tank, Open Top, 3 tanks for 6 mont	18	mo		$1,140.00			$0	$20,520	$0	$0	$20,520
5.4 Transport/Dispose IDW Off-site	50	tanker	$2,575.00				$128,750	$0	$0	$0	$128,750
5.5 Extraction Pumps, 4" dia., 0.3-7 gpm, 321-520 head	22	ea	$2,395.00				$52,690	$0	$0	$0	$52,690
5.6 Extraction Pumps, 4" dia., 21-32 gpm, 121-160 head	16	ea	$1,785.00				$28,560	$0	$0	$0	$28,560
5.7 Extraction Pumps, 4" dia., 21-32 gpm, 61-120 head	10	ea	$1,658.00				$16,580	$0	$0	$0	$16,580
5.8 Vault Boxes and Misc. Piping/Valves at Well Head	41	ea		$399.50	$299.63		$0	$16,380	$12,285	$0	$28,664
5.9 Collection Piping/Fittings, 4"/8" PE	800	lf		$8.21	$16.91	$4.93	$0	$6,568	$13,528	$3,944	$24,040
5.10 Collection Piping/Fittings, 6"/10" PE	1,600	lf		$12.82	$17.49	$5.05	$0	$20,512	$27,984	$8,080	$56,576
5.11 Transfer Piping/Fittings, 6"/10" PE	*1,050*	*lf*		*$12.82*	*$17.49*	*$5.05*	$0	*$13,461*	$18,365	$5,303	$37,128
5.12 Transfer Pumps, 120 gpm, 5 HP	2	ea		$3,999.00	$1,552.00		$0	$7,998	$3,104	$0	$11,102
5.13 Transfer Pumps, 190 gpm, 10 HP	2	ea		$3,587.00	$998.15		$0	$7,174	$1,996	$0	$9,170
5.14 Leak Detection Monitor	3,450	lf		$9.50	$4.75		$0	$32,775	$16,388	$0	$49,163

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Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
5.15 Leak Detection Loop	10	ea		$580.00	$1,109.00		$0	$5,800	$11,090	$0	$16,890
5.16 Highway/Railroad Boring	30	lf	$305.00				$9,150	$0	$0	$0	$9,150
5.17 ~~Boring Preparation (pits, mob/demob)~~	1	ls	~~$6,000.00~~				~~$6,000~~	~~$0~~	~~$0~~	$0	~~$6,000~~
5.18 Install New Sump, 8' by 8' by 10' deep	2	ea		$2,425.00	$1,300.00	$560.00	$0	$4,850	$2,600	$1,120	$8,570
6 GROUNDWATER TREATMENT SYSTEM - CENTER OF PLUME											
6.1 Building Foundation	1,500	sf	$3.87				$5,805	$0	$0	$0	$5,805
6.2 Treatment Building	1,500	sf	$11.03				$16,545	$0	$0	$0	$16,545
6.3 Building Misc. (doors/vent/insulation/misc.)	1	ls	$2,500.00				$2,500	$0	$0	$0	$2,500
6.4 Equalization Tank (12,000 gal)	1	ea		$8,027.00	$1,267.00	$221.47	$0	$8,027	$1,267	$221	$9,515
6.5 Top Mounted Mixer (7.5 HP)	1	ea		$35,438.00	$1,215.00		$0	$35,438	$1,215	$0	$36,653
6.6 Centrifugal Transfer Pump, 400 gpm (15 HP)	2	ea		$3,490.00	$520.33		$0	$6,980	$1,041	$0	$8,021
6.7 Bag Filter, 400 gpm, dual element, 25 micron	1	ea		$7,300.00	$1,095.00		$0	$7,300	$1,095	$0	$8,395
6.8 Air Stripper, 6 ft dia, 46 ft high, packed column	1	ea		$105,230.00	$5,209.00	$881.12	$0	$105,230	$5,209	$881	$111,320
6.9 Centrifugal Transfer Pump, 400 gpm (20 HP)	2	ea		$3,490.00	$520.33		$0	$6,980	$1,041	$0	$8,021
6.10 Offgas Heater, 40 kW	1	ea		$6,428.00	$615.47		$0	$6,428	$615	$0	$7,043
6.11 GAC, vapor-phase, 13,600 lbs	2	ea		$52,349.00	$506.82	$84.59	$0	$104,698	$1,014	$169	$105,881
6.12 GAC, liquid-phase, 20,000 lbs	*2*	*ea*		*$77,681.00*	*$10,890.00*	*$2,941.00*	$0	*$155,362*	*$21,780*	$5,882	*$183,024*
6.13 Instruments and Controls	1	ls		$15,000.00	$700.00		$0	$15,000	$700	$0	$15,700
6.14 Plumb System	1	ls		$6,000.00	$4,000.00		$0	$6,000	$4,000	$0	$10,000
6.15 System Start-Up and Testing	1	ls		$1,000.00	$13,260.00		$0	$1,000	$13,260	$0	$14,260
7 ELECTRICAL COSTS - EXTRACTION AND TREATMENT - CENTER OF PLUME											
7.1 30 amp Safety Switch, Non-Fused, 600V, Nema 4 Enclos	50	ea		$705.00	$88.00	$0.00	$0	$35,250	$4,400	$0	$39,650
7.2 Electrical Manholes, 4' x 6' x 7'	10	ea		$1,175.00	$670.00	$280.00	$0	$11,750	$6,700	$2,800	$21,250
7.3 Underground Marking Tape, 6" wide	2500	ft		$0.28	$0.26	$0.00	$0	$700	$650	$0	$1,350
7.4 2" PVC, Schedule 40 Conduit	56800	ft		$0.97	$1.47	$0.00	$0	$55,096	$83,496	$0	$138,592
7.5 1/C #8, THHN, Copper Conductor, Stranded	1896	clf		$15.60	$33.00	$0.00	$0	$29,578	$62,568	$0	$92,146
7.6 1/C #10, THHN, Copper Conductor, Stranded	648	clf		$9.30	$26.50	$0.00	$0	$6,026	$17,172	$0	$23,198
7.7 1/C #12, THHN, Copper Conductor, Stranded	1616	clf		$6.05	$24.00	$0.00	$0	$9,777	$38,784	$0	$48,561
7.8 Trench Excavation, 48"D x 36"W	1067	cy		$0.00	$4.04	$4.98	$0	$0	$4,311	$5,314	$9,624
7.9 Trench Bedding, Sand, 6"D	134	cy		$3.50	$3.85	$1.35	$0	$469	$516	$181	$1,166
7.10 Trench Backfill	933	cy		$0.00	$0.50	$0.49	$0	$0	$467	$457	$924
7.11 3/4" PVC Coated Conduit	1000	ft		$3.78	$3.77	$0.00	$0	$3,780	$3,770	$0	$7,550
7.12 3/4" PVC Coated Elbows	300	ea		$9.50	$11.00	$0.00	$0	$2,850	$3,300	$0	$6,150
7.13 3/4" Conduit Hub	100	ea		$23.50	$16.50	$0.00	$0	$2,350	$1,650	$0	$4,000
7.14 Junction Box 6" x 6" x 6", Nema 4	50	ea		$139.00	$66.00	$0.00	$0	$6,950	$3,300	$0	$10,250
7.15 3/4" dia, 10' long, Copper Ground Rod	50	ea		29.50	60.00	0.00	$0	$1,475	$3,000	$0	$4,475
7.16 Bare Copper Wire, #8 Solid	10	clf		$14.00	$24.00	$0.00	$0	$140	$240	$0	$380
7.17 Ground Clamps, Heavy Duty, Bronze	50	ea		$11.70	$33.00	$0.00	$0	$585	$1,650	$0	$2,235

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CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 9: Groundwater Containment of Center of Plume and Valley Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
7.18 Heat Trace, Shielded, Self Regulating, 3 W/ft	5	clf		$470.00	$43.82	$0.00	$0	$2,350	$219	$0	$2,569
7.19 Heat Trace Power Connection Box	50	ea		$78.00	$34.43	$0.00	$0	$3,900	$1,722	$0	$5,622
7.20 Heat Trace End Seal	50	ea		$20.25	$6.26	$0.00	$0	$1,013	$313	$0	$1,326
7.21 Motor Control Center, 10 Vert Sections, 42,000 RMS	10	sect		$1,800.00	$330.00	$0.00	$0	$18,000	$3,300	$0	$21,300
7.22 Copper Bus Bars for Item 1 (Add On)	10	sect		$164.00	$0.00	$0.00	$0	$1,640	$0	$0	$1,640
7.23 NEMA 12 Enclosures (Add On)	10	sect		$94.50	$0.00	$0.00	$0	$945	$0	$0	$945
7.24 Indicating Lights for Starters (Add On)	58	ea		$73.50	$16.50	$0.00	$0	$4,263	$957	$0	$5,220
7.25 Selector Switch for Starters (Add On)	58	ea		$73.50	$16.50	$0.00	$0	$4,263	$957	$0	$5,220
7.26 Motor Control Center, 7 Vert Sections, 42,000 RMS	7	sect		$1,800.00	$330.00	$0.00	$0	$12,600	$2,310	$0	$14,910
7.27 Copper Bus Bars for Item 1 (Add On)	7	sect		$164.00	$0.00	$0.00	$0	$1,148	$0	$0	$1,148
7.28 NEMA 12 Enclosures (Add On)	7	sect		$94.50	$0.00	$0.00	$0	$662	$0	$0	$662
7.29 Indicating Lights for Starters (Add On)	8	ea		$73.50	$16.50	$0.00	$0	$588	$132	$0	$720
7.30 Selector Switch for Starters (Add On)	8	ea		$73.50	$16.50	$0.00	$0	$588	$132	$0	$720
7.31 Transformer, 25KVA	1	ea		$1,175.00	$530.00	$0.00	$0	$1,175	$530	$0	$1,705
7.32 Distribution Panelboard	1	ea		$2,275.00	$1,100.00	$0.00	$0	$2,275	$1,100	$0	$3,375
7.33 Auxiliary Contacts	64	ea		$201.00	$16.50	$0.00	$0	$12,864	$1,056	$0	$13,920
7.34 3/4" Rigid Steel Conduit, Galvanized	2000	ft		$1.81	$3.30	$0.00	$0	$3,620	$6,600	$0	$10,220
7.35 1" Rigid Steel Conduit, Galvanized	200	ft		$2.53	$4.06	$0.00	$0	$506	$812	$0	$1,318
7.36 4" Rigid Steel Conduit, Galvanized	50	ft		$16.50	$13.20	$0.00	$0	$825	$660	$0	$1,485
7.37 1/C #12 THHN Copper Conductor	200	clf		$6.05	$24.00	$0.00	$0	$1,210	$4,800	$0	$6,010
7.38 1/C #10 THHN Copper Conductor	5	clf		$9.30	$26.50	$0.00	$0	$47	$133	$0	$179
7.39 1/C #8 THHN Copper Conductor	5	clf		$15.60	$33.00	$0.00	$0	$78	$165	$0	$243
7.40 1/C #500 KCMIL Copper Conductor	10	clf		$425.00	$165.00	$0.00	$0	$4,250	$1,650	$0	$5,900
7.41 Treatment Plant Lighting/Distr. System	5000	sf		$2.85	$4.33	$0.00	$0	$14,250	$21,650	$0	$35,900
7.42 30 amp, Safety Switch, 600V, Non-Fused	14	ea		$181.00	$85.00	$0.00	$0	$2,534	$1,190	$0	$3,724
7.43 Treatment Plant Lightning System	1	pkg		$10,000.00	$3,000.00	$0.00	$0	$10,000	$3,000	$0	$13,000
7.44 Treatment Plant Grounding System	1	pkg		$5,000.00	$2,000.00	$0.00	$0	$5,000	$2,000	$0	$7,000
8 GROUNDWATER DISCHARGE TO WEST BRANCH - CENTER OF PLUME											
8.1 Discharge Piping, 8" PE	2,000	ft		$5.05	$6.41	$3.20	$0	$10,100	$12,820	$6,400	$29,320
8.2 Outfall Structure (Headwall)	1	ea		$440.00	$1,100.00	$375.00	$0	$440	$1,100	$375	$1,915
9 SITE RESTORATION - CENTER OF PLUME											
9.1 Top Dress Soil	2,500	sy		$2.91	$1.53		$0	$7,275	$3,825	$0	$11,100
9.2 Fine Grading & Seeding	2,500	sy		$0.29	$1.13	$0.20	$0	$725	$2,825	$500	$4,050
9.3 Pavement Repair/Replacement	10	sy		$6.05	$16.10	$1.91	$0	$61	$161	$19	$241
10 GROUNDWATER EXTRACTION SYSTEM MODIFICATION - VALLEY PLUME											
10.1 Install Pumping Wells, (22 @ 400')	8,800	ft	$35.00				$308,000	$0	$0	$0	$308,000
10.2 Well Development (2 hr/well)	44	hr	$35.00				$1,540	$0	$0	$0	$1,540

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Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
10.3 21,000 Gallon Steel Tank, Open Top, 3 tanks/6 mo	18	mo		$1,140.00			$0	$20,520	$0	$0	$20,520
10.4 Transport/Dispose IDW Off-site	33	tanker	$2,575.00				$84,975	$0	$0	$0	$84,975
10.5 Extraction Pumps, 4" dia., 0.3-7 gpm, 321-520 head	22	ea	$2,395.00				$52,690	$0	$0	$0	$52,690
10.6 Vault Boxes and Misc. Piping/Valves at Well Head	22	ea		$399.50	$299.63		$0	$8,789	$6,592	$0	$15,381
10.7 Collection Piping/Fittings, 16"/24" PE	1,600	lf		$57.81	$38.95	$11.38	$0	$92,496	$62,320	$18,208	$173,024
10.8 Transfer Piping/Fittings, 16"/24" PE	400	lf		$57.81	$38.95	$11.38	$0	$23,124	$15,580	$4,552	$43,256
10.9 Transfer Pumps, 120 gpm, 5 HP	2	ea		$3,999.00	$1,552.00		$0	$7,998	$3,104	$0	$11,102
10.10 Transfer Pumps, 190 gpm, 10 HP		ea		$3,587.00	$998.15		$0	$0	$0	$0	$0
10.11 Leak Detection Monitor	2,000	lf		$9.50	$4.75		$0	$19,000	$9,500	$0	$28,500
10.12 Leak Detection Loop	2	ea		$580.00	$1,109.00		$0	$1,160	$2,218	$0	$3,378
10.13 Highway Boring	80	lf	$305.00				$24,400	$0	$0	$0	$24,400
10.14 Boring Preparation (pits, mob/demob)	1	ls	$6,000.00				$6,000	$0	$0	$0	$6,000
10.15 Install New Sump, 8' by 8' by 10' deep	1	ea		$2,425.00	$1,300.00	$560.00	$0	$2,425	$1,300	$560	$4,285
11 GROUNDWATER TREATMENT SYSTEM - VALLEY PLUME											
11.1 Building Foundation	2,000	sf	$3.87				$7,740	$0	$0	$0	$7,740
11.2 Treatment Building	2,000	sf	$11.03				$22,060	$0	$0	$0	$22,060
11.3 Building Misc. (doors/vent/insulation/misc.)	2	ls	$1,500.00				$3,000	$0	$0	$0	$3,000
11.4 Equalization Tank (7,500 gal)	2	ea		$6,483.00	$1,056.00	$176.00	$0	$12,966	$2,112	$352	$15,430
11.5 Top Mounted Mixer (5 HP)	2	ea		$22,113.00	$1,215.00		$0	$44,226	$2,430	$0	$46,656
11.6 Centrifugal Transfer Pump, 250 gpm (10 HP)	4	ea		$2,385.00	$390.00		$0	$9,540	$1,560	$0	$11,100
11.7 GAC, liquid-phase, 10,000 lbs	4	ea		$58,000.00	$8,890.00	$2,941.00	$0	$232,000	$35,560	$11,764	$279,324
11.8 Instruments and Controls	2	ls		$5,000.00	$700.00		$0	$10,000	$1,400	$0	$11,400
11.9 Plumb System	*2*	*ls*		*$3,000.00*	*$2,000.00*		*$0*	*$6,000*	*$4,000*	*$0*	*$10,000*
11.10 System Start-Up and Testing	2	ls		$1,000.00	$7,000.00		$0	$2,000	$14,000	$0	$16,000
12 ELECTRICAL COSTS - EXTRACTION AND TREATMENT - VALLEY PLUME											
12.1 30 amp Safety Switch, Non-Fused, 600V, NEMA 4 Encl	26	ea		$705.00	$88.00	$0.00	$0	$18,330	$2,288	$0	$20,618
12.2 Electrical Manholes, 4' x 6' x 7'	6	ea		$1,175.00	$670.00	$280.00	$0	$7,050	$4,020	$1,680	$12,750
12.3 Underground Marking Tape, 6" wide	2000	ft		$0.28	$0.26	$0.00	$0	$560	$520	$0	$1,080
12.4 2" PVC, Schedule 40 Conduit	20000	ft		$0.97	$1.47	$0.00	$0	$19,400	$29,400	$0	$48,800
12.5 1/C #8, THHN, Copper Conductor, Stranded	480	clf		$15.60	$33.00	$0.00	$0	$7,488	$15,840	$0	$23,328
12.6 1/C #10, THHN, Copper Conductor, Stranded	360	clf		$9.30	$26.50	$0.00	$0	$3,348	$9,540	$0	$12,888
12.7 1/C #12, THHN, Copper Conductor, Stranded	24	clf		$6.05	$24.00	$0.00	$0	$145	$576	$0	$721
12.8 Trench Excavation, 48"D x 36"W x 2000'L	778	cy		$0.00	$4.04	$4.98	$0	$0	$3,143	$3,874	$7,018
12.9 Trench Bedding, Sand, 6"D	111	cy		$3.50	$3.85	$1.35	$0	$389	$427	$150	$966
12.10 Trench Backfill	889	cy		$0.00	$0.50	$0.49	$0	$0	$445	$436	$880
12.11 3/4" PVC Coated Conduit	520	ft		$3.78	$3.77	$0.00	$0	$1,966	$1,960	$0	$3,926
12.12 3/4" PVC Coated Elbows	156	ea		$9.50	$11.00	$0.00	$0	$1,482	$1,716	$0	$3,198
12.13 3/4" Conduit Hub	52	ea		$23.50	$16.50	$0.00	$0	$1,222	$858	$0	$2,080

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Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
12.14 Junction Box 6" x 6" x 6", Nema 4	26	ea		$139.00	$66.00	$0.00	$0	$3,614	$1,716	$0	$5,330
12.15 3/4" dia, 10' long, Copper Ground Rod	24	ea		29.50	60.00	0.00	$0	$708	$1,440	$0	$2,148
12.16 Bare Copper Wire, #8 Solid	5	clf		$14.00	$24.00	$0.00	$0	$70	$120	$0	$190
12.17 Ground Clamps, Heavy Duty, Bronze	24	ea		$11.70	$33.00	$0.00	$0	$281	$792	$0	$1,073
12.18 Heat Trace, Shielded, Self Regulating, 3 W/ft	3	clf		$470.00	$43.82	$0.00	$0	$1,410	$131	$0	$1,541
12.19 Heat Trace Power Connection Box	26	ea		$78.00	$34.43	$0.00	$0	$2,028	$895	$0	$2,923
12.20 Heat Trace End Seal	26	ea		$20.25	$6.26	$0.00	$0	$527	$163	$0	$689
12.21 Motor Control Center, 6 Vert Sect, 42,000 RMS	6	sect		$1,800.00	$330.00	$0.00	$0	$10,800	$1,980	$0	$12,780
12.22 *Copper Bus Bars for Item 1 (Add On)*	6	sect		$164.00	$0.00	$0.00	$0	$984	$0	$0	$984
12.23 NEMA 12 Enclosures (Add On)	6	sect		$94.50	$0.00	$0.00	$0	$567	$0	$0	$567
12.24 Indicating Lights for Starters (Add On)	20	ea		$73.50	$16.50	$0.00	$0	$1,470	$330	$0	$1,800
12.25 Selector Switch for Starters (Add On)	20	ea		$73.50	$16.50	$0.00	$0	$1,470	$330	$0	$1,800
12.26 Transformer, 25KVA	1	ea		$1,175.00	$530.00	$0.00	$0	$1,175	$530	$0	$1,705
12.27 Distribution Panelboard	1	ea		$2,275.00	$1,100.00	$0.00	$0	$2,275	$1,100	$0	$3,375
12.28 Auxiliary Contacts	40	ea		$201.00	$16.50	$0.00	$0	$8,040	$660	$0	$8,700
12.29 Motor Control Center, 6 Vert Sections, 42,000 RMS	6	sect		$1,800.00	$330.00	$0.00	$0	$10,800	$1,980	$0	$12,780
12.30 Copper Bus Bars for Item 1 (Add On)	6	sect		$164.00	$0.00	$0.00	$0	$984	$0	$0	$984
12.31 NEMA 12 Enclosures (Add On)	6	sect		$94.50	$0.00	$0.00	$0	$567	$0	$0	$567
12.32 Indicating Lights for Starters (Add On)	20	ea		$73.50	$16.50	$0.00	$0	$1,470	$330	$0	$1,800
12.33 Selector Switch for Starters (Add On)	20	ea		$73.50	$16.50	$0.00	$0	$1,470	$330	$0	$1,800
12.34 Transformer, 25KVA	1	ea		$1,175.00	$530.00	$0.00	$0	$1,175	$530	$0	$1,705
12.35 *Distribution Panelboard*	1	ea		$2,275.00	$1,100.00	$0.00	$0	$2,275	$1,100	$0	$3,375
12.36 Auxiliary Contacts	40	ea		$201.00	$16.50	$0.00	$0	$8,040	$660	$0	$8,700
12.37 3/4" Rigid Steel Conduit, Galvanized	1500	ft		$1.81	$3.30	$0.00	$0	$2,715	$4,950	$0	$7,665
12.38 1" Rigid Steel Conduit, Galvanized	400	ft		$2.53	$4.06	$0.00	$0	$1,012	$1,624	$0	$2,636
12.39 4" Rigid Steel Conduit, Galvanized	100	ft		$16.50	$13.20	$0.00	$0	$1,650	$1,320	$0	$2,970
12.40 1/C #12 THHN Copper Conductor	180	clf		$6.05	$24.00	$0.00	$0	$1,089	$4,320	$0	$5,409
12.41 1/C #10 THHN Copper Conductor	5	clf		$9.30	$26.50	$0.00	$0	$47	$133	$0	$179
12.42 1/C #8 THHN Copper Conductor	5	clf		$15.60	$33.00	$0.00	$0	$78	$165	$0	$243
12.43 1/C #500 KCMIL Copper Conductor	20	clf		$425.00	$165.00	$0.00	$0	$8,500	$3,300	$0	$11,800
12.44 Treatment Plant Lighting/Distr. System	2000	sf		$2.85	$4.33	$0.00	$0	$5,700	$8,660	$0	$14,360
12.45 30 amp, Safety Switch, 600V, Non-Fused	14	ea		$181.00	$85.00	$0.00	$0	$2,534	$1,190	$0	$3,724
12.46 Treatment Plant Lightning System	2	pkg		$10,000.00	$3,000.00	$0.00	$0	$20,000	$6,000	$0	$26,000
12.47 Treatment Plant Grounding System	2	pkg		$5,000.00	$2,000.00	$0.00	$0	$10,000	$4,000	$0	$14,000
13 *GROUNDWATER DISCHARGE TO WEST BRANCH - VALLEY PLUME*											
13.1 Discharge Piping, 16" PE	400	ft		$17.14	$11.35	$6.24	$0	$6,856	$4,540	$2,496	$13,892
13.2 Pumps - 250 GPM, 15 HP	2	ea		$3,889.00	$354.77		$0	$7,778	$710	$0	$8,488
13.3 Outfall Structures (Headwall)	2	ea		$440.00	$1,100.00	$375.00	$0	$880	$2,200	$750	$3,830

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
14 SITE RESTORATION - VALLEY PLUME											
14.1 Top Dress Soil	1,667	sy		$2.91	$1.53		$0	$4,851	$2,551	$0	$7,401
14.2 Fine Grading & Seeding	1,667	sy		$0.29	$1.13	$0.20	$0	$483	$1,884	$333	$2,701
14.3 Pavement Repair/Replacement	10	sy		$6.05	$16.10	$1.91	$0	$61	$161	$19	$241
Subtotal							$1,820,935	$1,608,115	$937,346	$89,879	$4,456,274
Local Area Adjustments							100.0%	100.0%	124.8%	124.8%	
Subtotal							$1,820,935	$1,608,115	$1,169,807	$112,168	$4,711,026
Overhead on Labor Cost @ 30%									$350,942		$350,942
G & A on Labor Cost @ 10%									$116,981		$116,981
G & A on Material Cost @ 10%								$160,812			$160,812
G & A on Subcontract Cost @ 10%							$182,094				$182,094
Total Direct Cost							$2,003,029	$1,768,927	$1,637,730	$112,168	$5,521,854
Indirects on Total Direct Cost @ 30%											$1,656,556
Profit on Total Direct Cost @ 10%											$552,185
Subtotal											$7,730,596
Health & Safety Monitoring @ 2%											$154,612
Total Field Cost											$7,885,207
Contingency on Total Field Cost @ 20%											$1,577,041
Engineering on Total Field Cost @ 10%											$788,521
TOTAL COST											**$10,250,770**

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Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 9: Groundwater Containment of Center of Plume and Valley Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Operation and Maintenance Costs per Year - Center of Plume

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
YEAR 1						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment System and Electrical Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Changeout/Regeneration of Spent Carbon	680,000	lb.	$3.00	$2,040,000	Replace canister 50 times
5	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
6	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
7	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during year 1				$2,234,529	
YEAR 2						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment System and Electrical Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Changeout/Regeneration of Spent Carbon	476,000	lb.	$3.00	$1,428,000	Replace canister 35 times
5	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
6	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
7	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during year 2				$1,622,529	
YEAR 3						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment System and Electrical Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Changeout/Regeneration of Spent Carbon	204,000	lb.	$3.00	$612,000	Replace canister 15 times
5	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
6	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
7	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during year 3				$806,529	

AR300298

CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 9: Groundwater Containment of Center of Plume and Valley Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Operation and Maintenance Costs per Year - Center of Plume

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
YEAR 4						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment System and Electrical Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Changeout/Regeneration of Spent Carbon	108,800	lb.	$3.00	$326,400	Replace canister 8 times
5	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
6	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
7	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during year 4				$520,929	
YEARS 5 THROUGH 10						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment System and Electrical Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Changeout/Regeneration of Spent Carbon	54,400	lb.	$3.00	$163,200	Replace canister 4 times
5	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
6	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
7	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during years 5-10				$357,729	

AR300299

CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 9: Groundwater Containment of Center of Plume and Valley Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Operation and Maintenance Costs per Year - Center of Plume

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
YEARS 11 THROUGH 20						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment System and Electrical Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Changeout/Regeneration of Spent Carbon	27,200	lb.	$3.00	$81,600	Replace canister 2 times
5	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
6	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
7	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during years 11-20				$276,129	
YEARS 21 THROUGH 30						
1	Energy - Electric	1,676,500	kWh	$0.06	$100,590	
2	Extraction System Maintenance, Labor & Supplies	1	ls	$16,528.16	$16,528	5% of Installation Cost
3	Treatment System and Electrical Maintenance	1	ls	$54,890.67	$54,891	5% of Installation Cost
4	Changeout/Regeneration of Spent Carbon	13,600	lb.	$3.00	$40,800	Replace canister 1 time
5	Sample/analysis influent/effluent from system	24	ea	$155.00	$3,720	Two samples per month, TSS, chl VOCs, iron, manganese
6	Sample/analysis air stripper offgas from system	8	ea	$350.00	$2,800	Two samples per quarter, chlorinated VOCs
7	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for One Year Operation during years 21-30				$235,329	

CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 9: Groundwater Containment of Center of Plume and Valley Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Annual Sampling Cost

Item	Cost per Sampling Round Years 1 thru 30*	Item Cost per 5 Years	Notes
Sampling	$11,400		Collect groundwater samples, per sampling period (twice per year with local labor)
Analysis/Water	$6,500		Water samples, per sampling period, (including lab and in-house QA) for TCL VOC's and TAL metals. Monitoring from 20 locations for 30 years.
Report	$4,000		Obtain lab, prepare sampling plan, document sampling events and results
Maintenance		$30,000	Extraction well inspection, cleaning, antifouling, and maintenance
Site Review	$0	$10,000	Review of documents and data evaluation/recommendations; preparation of summary reports for 5-year CERCLA reviews
TOTALS	$21,900	$40,000	

* Semi-annually years 1 through 30

AR300301

CROSSLEY FARM SITE
Berks County, Pennsylvania
Groundwater Feasibility Study
Alternative 9: Groundwater Containment of Center of Plume and Valley Plume, On-Site Treatment, and Discharge to West Branch Perkiomen Creek
Present Worth Analysis

Year	Capital Cost	Operation and Maintenance Cost Center of Plume	Operation and Maintenance Cost Valley Plume	Annual Cost	Total Year Cost	Annual Discount Rate st 7%	Present Worth
0	$10,250,770				$10,250,770	1.000	$10,250,770
1		$2,234,529	$201,220	$43,800	$2,479,549	0.935	$2,318,378
2		$1,622,529	$321,220	$43,800	$1,987,549	0.873	$1,735,130
3		$806,529	$201,220	$43,800	$1,051,549	0.816	$858,064
4		$520,929	$201,220	$43,800	$765,949	0.763	$584,419
5		$357,729	$201,220	$83,800	$642,749	0.713	$458,280
6		$357,729	$201,220	$43,800	$602,749	0.666	$401,431
7		$357,729	$201,220	$43,800	$602,749	0.623	$375,513
8		$357,729	$201,220	$43,800	$602,749	0.582	$350,800
9		$357,729	$201,220	$43,800	$602,749	0.544	$327,896
10		$357,729	$321,220	$83,800	$762,749	0.508	$387,477
11		$276,129	$201,220	$43,800	$521,149	0.475	$247,546
12		$276,129	$201,220	$43,800	$521,149	0.444	$231,390
13		$276,129	$201,220	$43,800	$521,149	0.415	$216,277
14		$276,129	$201,220	$43,800	$521,149	0.388	$202,206
15		$276,129	$201,220	$83,800	$561,149	0.362	$203,136
16		$276,129	$201,220	$43,800	$521,149	0.339	$176,670
17		$276,129	$201,220	$43,800	$521,149	0.317	$165,204
18		$276,129	$201,220	$43,800	$521,149	0.296	$154,260
19		$276,129	$201,220	$43,800	$521,149	0.277	$144,358
20		$276,129	$201,220	$83,800	$561,149	0.258	$144,776
21		$235,329	$201,220	$43,800	$480,349	0.242	$116,244
22		$235,329	$201,220	$43,800	$480,349	0.226	$108,559
23		$235,329	$201,220	$43,800	$480,349	0.211	$101,354
24		$235,329	$201,220	$43,800	$480,349	0.197	$94,629
25		$235,329	$201,220	$83,800	$520,349	0.184	$95,744
26		$235,329	$201,220	$43,800	$480,349	0.172	$82,620
27		$235,329	$201,220	$43,800	$480,349	0.161	$77,336
28		$235,329	$201,220	$43,800	$480,349	0.150	$72,052
29		$235,329	$201,220	$43,800	$480,349	0.141	$67,729
30		$235,329	$201,220	$83,800	$520,349	0.131	$68,166

AR300302

Present Worth Analysis

Year	Capital Cost	Operation and Maintenance Cost Center of Plume	Operation and Maintenance Cost Valley Plume	Annual Cost	Total Year Cost	Annual Discount Rate st 7%	Present Worth
						TOTAL PRESENT WORTH	**$20,818,415**

CROSSLEY FARM SITE
Berks Count, Pennsylvania
Sediment
Alternative 11: Sediment Monitoring
Annual Cost

Item	Cost per Sampling Round Years 1 thru 30	Item Cost per 5 Years	Notes
Sampling	$2,050		Collect sediment samples, per sampling period (twice per year with local labor)
Analysis/Sediment	$60		Sediment samples, per sampling period, (including lab and in-house QA) chromium. Monitoring from 2 locations for 5 years.
Report	$4,000		Obtain lab, prepare sampling plan, document sampling events and results
Site Review	$0	$10,000	Review of documents and data evaluation/recommendations
TOTALS	$6,110	$10,000	

AR300304

CROSSLEY FARM SITE
Berks Count, Pennsylvania
Sediment
Alternative 11: Sediment Monitoring
Present Worth Analysis

Year	Capital Cost	Operation and Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$0			$0	1.000	$0
1		$0	$12,220	$12,220	0.935	$11,426
2		$0	$12,220	$12,220	0.873	$10,668
3		$0	$12,220	$12,220	0.816	$9,972
4		$0	$12,220	$12,220	0.763	$9,324
5		$0	$22,220	$22,220	0.713	$15,843
					TOTAL PRESENT WORTH	**$57,232**

AR300305

CROSSLEY FARM SITE
Berks County, Pennsylvania
Sediment Feasibility Study
Alternative 12: Excavation, Off-Site Treatment and Disposal
Capital Cost

Item	Quantity	Unit	Unit Cost: Subcontract	Unit Cost: Material	Unit Cost: Labor	Unit Cost: Equipment	Total Cost: Subcontract	Total Cost: Material	Total Cost: Labor	Total Cost: Equipment	Total Direct Cost
1 PROJECT DOCUMENTS/INSTITUTIONAL CONTROLS											
1.1 Prepare Documents & Plans including Permits	200	hr			$40.00		$0	$0	$8,000	$0	$8,000
2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT											
2.4 Construction Survey	1	ls	$500.00				$500	$0	$0	$0	$500
2.5 Equipment Mobilization/Demobilization	3	ea			$45.50	$229.00	$0	$0	$137	$687	$824
2.8 Professional Oversight (1p * 5 days)	1	wk			$4,000.00		$0	$0	$4,000	$0	$4,000
3 DECONTAMINATION											
3.1 Equipment Decon Pad	1	ls		$500.00	$450.00	$155.00	$0	$500	$450	$155	$1,105
3.2 PPE (2 p * 5 days * 1 weeks)	10	day		$30.00			$0	$300	$0	$0	$300
3.3 Disposal of Decon Waste)	1	ls	$300.00				$300	$0	$0	$0	$300
4 PRE-EXCAVATION CHARACTERIZATION/TESTING											
4.1 Sampling and analysis	1	ls	$2,000.00				$2,000	$0	$0	$0	$2,000
5 SEDIMENT EXCAVATION/DISPOSAL											
5.1 Excavator w/ Operator, 10' x 20' x 0.5' Area, Containerize	3	day			$514.95	$1,017.00	$0	$0	$1,545	$3,051	$4,596
5.2 Transportation and Disposal of Containerized Material	1	ls	$500.00				$500	$0	$0	$0	$500
5.3 Post-Excavation Sampling, 5 samples, chromium	5	ea	$30.00				$150	$0	$0	$0	$150
6 SITE RESTORATION											
6.1 Top Dress Soil	23	sy		$2.91	$1.53		$0	$67	$35	$0	$102
6.2 Fine Grading & Seeding	23	sy		$0.29	$1.13	$0.20	$0	$7	$26	$5	$37
Subtotal							$3,450	$874	$14,193	$3,898	$22,414
Local Area Adjustments							100.0%	100.0%	124.8%	124.8%	
Subtotal							$3,450	$874	$17,712	$4,864	$26,900
Overhead on Labor Cost @ 30%									$5,314		$5,314
G & A on Labor Cost @ 10%									$1,771		$1,771
G & A on Material Cost @ 10%								$87			$87
G & A on Subcontract Cost @ 10%							$345				$345
Total Direct Cost							$3,795	$961	$24,797	$4,864	$34,417
Indirects on Total Direct Cost @ 30%											$10,325
Profit on Total Direct Cost @ 10%											$3,442
Subtotal											$48,184
Health & Safety Monitoring @ 2%											$964

AR300306

CROSSLEY FARM SITE
Berks County, Pennsylvania
Sediment Feasibility Study
Alternative 12: Excavation, Off-Site Treatment and Disposal
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
Total Field Cost											$49,148
Contingency on Total Field Cost @ 20%											$9,830
Engineering on Total Field Cost @ 10%											$4,915
TOTAL COST											**$63,892**

AR300307

CROSSLEY FARM SITE
Berks County, Pennsylvania
Sediment Feasibility Study
Alternative 12: Excavation, Off-Site Treatment and Disposal
Present Worth Analysis

Year	Capital Cost	Operation and Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$63,892	$0	$0	$63,892	1.000	$63,892

TOTAL PRESENT WORTH **$63,892**

CROSSLEY FARM SITE
Berks County, Pennsylvania
Residential Drinking Water Supplies
Alternative 13: No Action
Sampling Cost

Item	Cost per Sampling Round Years 1 thru 30	Item Cost per 5 Years	Notes
Sampling	$26,800		Collect groundwater samples, per sampling period (one time per year with local labor)
Analysis/Water	$26,000		Water samples, per sampling period, (including lab and in-house QA) VOCs and metals. Monitoring from 80 wells for 30 years.
Report	$5,000		Obtain lab, prepare sampling plan, document sampling events and results
Site Review	$0	$12,000	Review of documents and data evaluation/recommendations
TOTALS	$57,800	$12,000	

Note: There are no capital or O&M costs for this alternative.

CROSSLEY FARM SITE
Berks County, Pennsylvania
Residential Drinking Water Supplies
Alternative 13: No Action
Present Worth Analysis

Year	Capital Cost	Operation and Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$0			$0	1.000	$0
1		$0	$57,800	$57,800	0.935	$54,043
2		$0	$57,800	$57,800	0.873	$50,459
3		$0	$57,800	$57,800	0.816	$47,165
4		$0	$57,800	$57,800	0.763	$44,101
5		$0	$69,800	$69,800	0.713	$49,767
6		$0	$57,800	$57,800	0.666	$38,495
7		$0	$57,800	$57,800	0.623	$36,009
8		$0	$57,800	$57,800	0.582	$33,640
9		$0	$57,800	$57,800	0.544	$31,443
10		$0	$69,800	$69,800	0.508	$35,458
11		$0	$57,800	$57,800	0.475	$27,455
12		$0	$57,800	$57,800	0.444	$25,663
13		$0	$57,800	$57,800	0.415	$23,987
14		$0	$57,800	$57,800	0.388	$22,426
15		$0	$69,800	$69,800	0.362	$25,268
16		$0	$57,800	$57,800	0.339	$19,594
17		$0	$57,800	$57,800	0.317	$18,323
18		$0	$57,800	$57,800	0.296	$17,109
19		$0	$57,800	$57,800	0.277	$16,011
20		$0	$69,800	$69,800	0.258	$18,008
21		$0	$57,800	$57,800	0.242	$13,988
22		$0	$57,800	$57,800	0.226	$13,063
23		$0	$57,800	$57,800	0.211	$12,196
24		$0	$57,800	$57,800	0.197	$11,387
25		$0	$69,800	$69,800	0.184	$12,843
26		$0	$57,800	$57,800	0.172	$9,942
27		$0	$57,800	$57,800	0.161	$9,306
28		$0	$57,800	$57,800	0.150	$8,670
29		$0	$57,800	$57,800	0.141	$8,150
30		$0	$69,800	$69,800	0.131	$9,144
					TOTAL PRESENT WORTH	**$743,112**

CROSSLEY FARM SITE
Berks County, Pennsylvania
Residential Drinking Water Supplies
Alternative 14: Point-of-Entry Treatment
Capital Cost

			Unit Cost				Total Cost				Total Direct
Item	Quantity	Unit	Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	Cost
1 PROJECT DOCUMENTS/INSTITUTIONAL CONTROLS											
1.1 Prepare Deed Restrictions	200	hr			$40.00		$0	$0	$8,000	$0	$8,000
Subtotal							$0	$0	$8,000	$0	$8,000
Local Area Adjustments							100.0%	100.0%	124.8%	124.8%	
Subtotal							$0	$0	$9,984	$0	$9,984
Overhead on Labor Cost @ 30%									$2,995		$2,995
G & A on Labor Cost @ 10%									$998		$998
G & A on Material Cost @ 10%								$0			$0
G & A on Subcontract Cost @ 10%							$0				$0
Total Direct Cost							$0	$0	$13,978	$0	$13,978
Indirects on Total Direct Cost @ 30%											$699
Profit on Total Direct Cost @ 10%											$1,398
Subtotal 3											$16,074
Health & Safety Monitoring @ 0%											$0
Total Field Cost											$16,074
Contingency on Total Field Cost @ 0%											$0
Engineering on Total Field Cost @ 0%											$0
TOTAL COST											**$16,074**

AR300311

CROSSLEY FARM SITE
Berks County, Pennsylvania
Residential Drinking Water Supplies
Alternative 14: Point-of-Entry Treatment
Operation and Maintenance Costs per Year

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
1	Installation of New Units	2	ea	$4,200	$8,400	
2	Maintenance of Treatment Units	45	ea	$400	$18,000	Four times a year at $100 each
	Cost for Year One				$26,400	
3	Installation of New Units	2	ea	$4,200	$8,400	
4	Maintenance of Treatment Units	47	ea	$400	$18,800	Four times a year at $100 each
	Cost for Year Two				$27,200	
5	Installation of New Units	2	ea	$4,200	$8,400	
6	Maintenance of Treatment Units	49	ea	$400	$19,600	Four times a year at $100 each
	Cost for Year Three				$28,000	
7	Installation of New Units	2	ea	$4,200	$8,400	
8	Maintenance of Treatment Units	51	ea	$400	$20,400	Four times a year at $100 each
	Cost for Year Four				$28,800	
9	Installation of New Units	2	ea	$4,200	$8,400	
10	Maintenance of Treatment Units	53	ea	$400	$21,200	Four times a year at $100 each
	Cost for Year Five				$29,600	
11	Installation of New Units	2	ea	$4,200	$8,400	
12	Maintenance of Treatment Units	55	ea	$400	$22,000	Four times a year at $100 each
	Cost for Year Six				$30,400	
13	Installation of New Units	2	ea	$4,200	$8,400	
14	Maintenance of Treatment Units	57	ea	$400	$22,800	Four times a year at $100 each
	Cost for Year Seven				$31,200	
15	Installation of New Units	2	ea	$4,200	$8,400	
16	Maintenance of Treatment Units	59	ea	$400	$23,600	Four times a year at $100 each
	Cost for Year Eight				$32,000	
17	Installation of New Units	2	ea	$4,200	$8,400	
18	Maintenance of Treatment Units	61	ea	$400	$24,400	Four times a year at $100 each
	Cost for Year Nine				$32,800	
19	Installation of New Units	2	ea	$4,200	$8,400	
20	Maintenance of Treatment Units	63	ea	$400	$25,200	Four times a year at $100 each
	Cost for Year Ten				$33,600	
21	Maintenance of Treatment Units	63	ea	$400	$25,200	Four times a year at $100 each
	Cost for Years Eleven thru Thirty				$25,200	

CROSSLEY FARM SITE
Berks County, Pennsylvania
Residential Drinking Water Supplies
Alternative 14: Point-of-Entry Treatment
Annual Sampling Cost

Item	Cost per Sampling Round Years 1 thru 30	Item Cost per 5 Years	Notes
Sampling	$42,000		Collect groundwater samples, per sampling period two times per year with local labor)
Analysis/Water	$39,000		Water samples, per sampling period, (including lab and in-house QA) VOCs and metals. Monitoring from 120 wells for 30 years.
Report	$5,000		Obtain lab, prepare sampling plan, document sampling events and results
Site Review	$0	$12,000	Review of documents and data evaluation/recommendations
TOTALS	$86,000	$12,000	

AR300313

CROSSLEY FARM SITE
Berks County, Pennsylvania
Residential Drinking Water Supplies
Alternative 14: Point-of-Entry Treatment
Present Worth Analysis

Year	Capital Cost	Operation and Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$16,074			$16,074	1.000	$16,074
1		$26,400	$172,000	$198,400	0.935	$185,504
2		$27,200	$172,000	$199,200	0.873	$173,902
3		$28,000	$172,000	$200,000	0.816	$163,200
4		$28,800	$172,000	$200,800	0.763	$153,210
5		$29,600	$184,000	$213,600	0.713	$152,297
6		$30,400	$172,000	$202,400	0.666	$134,798
7		$31,200	$172,000	$203,200	0.623	$126,594
8		$32,000	$172,000	$204,000	0.582	$118,728
9		$32,800	$172,000	$204,800	0.544	$111,411
10		$33,600	$184,000	$217,600	0.508	$110,541
11		$25,200	$172,000	$197,200	0.475	$93,670
12		$25,200	$172,000	$197,200	0.444	$87,557
13		$25,200	$172,000	$197,200	0.415	$81,838
14		$25,200	$172,000	$197,200	0.388	$76,514
15		$25,200	$184,000	$209,200	0.362	$75,730
16		$25,200	$172,000	$197,200	0.339	$66,851
17		$25,200	$172,000	$197,200	0.317	$62,512
18		$25,200	$172,000	$197,200	0.296	$58,371
19		$25,200	$172,000	$197,200	0.277	$54,624
20		$25,200	$184,000	$209,200	0.258	$53,974
21		$25,200	$172,000	$197,200	0.242	$47,722
22		$25,200	$172,000	$197,200	0.226	$44,567
23		$25,200	$172,000	$197,200	0.211	$41,609
24		$25,200	$172,000	$197,200	0.197	$38,848
25		$25,200	$184,000	$209,200	0.184	$38,493
26		$25,200	$172,000	$197,200	0.172	$33,918
27		$25,200	$172,000	$197,200	0.161	$31,749
28		$25,200	$172,000	$197,200	0.150	$29,580
29		$25,200	$172,000	$197,200	0.141	$27,805
30		$25,200	$184,000	$209,200	0.131	$27,405
					TOTAL PRESENT WORTH	**$2,519,598**

AR300314

CROSSLEY FARM SITE
Berks County, Pennsylvania
Residential Drinking Water Supplies
Alternative 15: Extend Existing Water Distribution System (from Bally)
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
1 PROJECT DOCUMENTS/INSTITUTIONAL CONTROLS											
1.1 Prepare Documents & Plans including Permits	200	hr			$40.00		$0	$0	$8,000	$0	$8,000
1.2 Prepare Deed Restrictions	100	hr			$40.00		$0	$0	$4,000	$0	$4,000
2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT											
2.1 Office Trailer (1)	24	mo	$345.00				$8,280	$0	$0	$0	$8,280
2.2 Field Office Support	24	mo		$135.00			$0	$3,240	$0	$0	$3,240
2.3 Storage Trailer (1)	24	mo	$85.00				$2,040	$0	$0	$0	$2,040
2.4 Construction Survey	1	ls	$10,000.00				$10,000	$0	$0	$0	$10,000
2.5 Equipment Mobilization/Demobilization	15	ea			$45.50	$229.00	$0	$0	$683	$3,435	$4,118
2.6 Site Utilities	24	mo	$1,000.00				$24,000	$0	$0	$0	$24,000
2.7 Professional Oversight (4p * 5 days)	208	mwk			$3,200.00		$0	$0	$665,600	$0	$665,600
3 WATER MAIN INSTALLATION											
3.1 Trench w/backfill (2' wide by 4' deep)	29600	lf			$2.75	$1.49	$0	$0	$81,400	$44,104	$125,504
3.2 Pipe Bedding	29600	lf		$0.57	$0.49	$0.40	$0	$16,872	$14,504	$11,840	$43,216
3.3 Ductile Iron Pipe, 8" (push-on joint)	29600	lf		$9.95	$5.10		$0	$294,520	$150,960	$0	$445,480
3.4 Elbows, Tees, other connections (20% of pipe cost)	29600	lf		$1.99	$1.02		$0	$58,904	$30,192	$0	$89,096
3.5 Gate Valves w/boxes	30	ea		$258.00	$195.00	$71.50	$0	$7,740	$5,850	$2,145	$15,735
3.6 Water Service (line to valve)	43	ea		$375.00	$380.00	$100.00	$0	$16,125	$16,340	$4,300	$36,765
3.7 Water Service, trenching (valve to house)	2150	lf			$0.99	$0.39	$0	$0	$2,129	$839	$2,967
3.8 Water Service, 1 1/2" copper pipe	2150	lf		$2.45	$3.99		$0	$5,268	$8,579	$0	$13,846
3.9 Connect System to House	43	ea		$150.00	$275.00		$0	$6,450	$11,825	$0	$18,275
3.10 Test/Clean/Disinfect Lines	33	mlf	$300.00	$100.00	$480.00	$200.00	$9,900	$3,300	$15,840	$6,600	$35,640
3.11 Tap-in Fee	43	ea	$500.00				$21,500	$0	$0	$0	$21,500
3.12 Stream Crossing	5	ea	$16,025.00				$80,125	$0	$0	$0	$80,125
3.13 Abandon 43 Existing Residential Wells	1	ls	$20,000.00				$20,000	$0	$0	$0	$20,000
5 PUMP STATIONS											
5.1 Purchase Property for Pump Stations (2 locations)	1	ls	$100,000.00				$100,000	$0	$0	$0	$100,000
5.2 Clear and Grub Property	1.5	acre			$1,125.00	$1,100.00	$0	$0	$1,688	$1,650	$3,338
5.3 Concrete Building Slab (3 @ 16' x 22')	1056	sf		$2.27	$2.10	$0.50	$0	$2,397	$2,218	$528	$5,143
5.4 Pump Building (3 @ 12' x 16')	576	sf		$46.66	$25.45	$12.73	$0	$26,876	$14,659	$7,332	$48,868
5.5 Centrifugal Pump (3 with 3 backup) 600 gpm/50 hp	6	ea		$6,850.00	$1,825.00		$0	$41,100	$10,950	$0	$52,050
5.6 Trench w/backfill (2' wide by 4' deep)	300	lf			$2.75	$1.49	$0	$0	$825	$447	$1,272
5.7 Pipe Bedding	300	lf		$0.57	$0.49	$0.40	$0	$171	$147	$120	$438
5.8 Ductile Iron Pipe, 8" (push-on joint)	300	lf		$9.95	$5.10		$0	$2,985	$1,530	$0	$4,515
5.9 Elbows, Tees, other connections (35% of pipe cost)	300			$3.48	$1.79		$0	$1,045	$536	$0	$1,580
5.10 Electrical Feed to Pumps	3	ea	$2,000.00				$6,000	$0	$0	$0	$6,000
5.11 Control Panels and Wiring	3	ea		$5,000.00	$1,000.00		$0	$15,000	$3,000	$0	$18,000
5.12 Interior and Exterior Lighting	3	ea	$2,000.00				$6,000	$0	$0	$0	$6,000

CROSSLEY FARM SITE
Berks County, Pennsylvania
Residential Drinking Water Supplies
Alternative 15: Extend Existing Water Distribution System (from Bally)
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost
5.13 Electrical Backup System, 100kW	3	ea		$22,500.00	$1,975.00	$420.00	$0	$67,500	$5,925	$1,260	$74,685
6 SITE RESTORATION											
6.1 Top Dress Soil, 4" deep	270	sy		$2.17	$0.25	$0.23	$0	$586	$68	$62	$716
6.2 Fine Grading & Seeding	270	sy		$0.29	$1.13	$0.20	$0	$78	$305	$54	$437
6.3 Replace Pavement	16333	sy		$9.60	$20.50	$2.43	$0	$156,797	$334,827	$39,689	$531,312
Subtotal							$287,845	$726,954	$1,392,576	$124,405	$2,531,780
Local Area Adjustments							100.0%	100.0%	124.8%	124.8%	
Subtotal							$287,845	$726,954	$1,737,935	$155,258	$2,907,992
Overhead on Labor Cost @ 30%									$521,381		$521,381
G & A on Labor Cost @ 10%									$173,794		$173,794
G & A on Material Cost @ 10%								$72,695			$72,695
G & A on Subcontract Cost @ 10%							$28,785				$28,785
Total Direct Cost							$316,630	$799,649	$2,433,109	$155,258	$3,704,646
Indirects on Total Direct Cost @ 30%											$1,111,394
Profit on Total Direct Cost @ 10%											$370,465
Subtotal 3											$5,186,504
Health & Safety Monitoring @ 0%											$0
Total Field Cost											$5,186,504
Contingency on Total Field Cost @ 20%											$1,037,301
Engineering on Total Field Cost @ 10%											$518,650
TOTAL COST											**$6,742,455**

AR300316

CROSSLEY FARM SITE
Berks County, Pennsylvania
Residential Drinking Water Supplies
Alternative 15: Extend Existing Water Distribution System (from Bally)
Operation and Maintenance Costs per Year

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
1	Energy - Electric	1,959,700	kWh	$0.06	$117,582	
2	Pump Station Maintenance, Labor & Supplies	1	ls	$8,227.01	$8,227	5% of Installation Cost
3	Quarterly Reports	4	ea	$4,000.00	$16,000	
	Subtotal Cost for Each Year of Operation				$141,809	

CROSSLEY FARM SITE
Berks County, Pennsylvania
Residential Drinking Water Supplies
Alternative 15: Extend Existing Water Distribution System (from Bally)
Annual Sampling Cost

Item	Cost per Sampling Round Years 1 thru 30	Item Cost per 5 Years	Notes
Sampling	$11,400		Collect groundwater samples, per sampling period once per year with local labor)
Analysis/Water	$6,500		Water samples, per sampling period, (including lab and in-house QA) for TCL VOC's and TAL metals. Monitoring from 20 locations for 30 years.
Report	$5,000		Obtain lab, prepare sampling plan, document sampling events and results
Site Review	$0	$12,000	Review of documents and data evaluation/recommendations
TOTALS	$22,900	$12,000	

AR300318

CROSSLEY FARM SITE
Berks County, Pennsylvania
Residential Drinking Water Supplies
Alternative 15: Extend Existing Water Distribution System (from Bally)
Present Worth Analysis

Year	Capital Cost	Operation and Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$6,742,455			$6,742,455	1.000	$6,742,455
1		$141,809	$22,900	$164,709	0.935	$154,003
2		$141,809	$22,900	$164,709	0.873	$143,791
3		$141,809	$22,900	$164,709	0.816	$134,403
4		$141,809	$22,900	$164,709	0.763	$125,673
5		$141,809	$34,900	$176,709	0.713	$125,994
6		$141,809	$22,900	$164,709	0.666	$109,696
7		$141,809	$22,900	$164,709	0.623	$102,614
8		$141,809	$22,900	$164,709	0.582	$95,861
9		$141,809	$22,900	$164,709	0.544	$89,602
10		$141,809	$34,900	$176,709	0.508	$89,768
11		$141,809	$22,900	$164,709	0.475	$78,237
12		$141,809	$22,900	$164,709	0.444	$73,131
13		$141,809	$22,900	$164,709	0.415	$68,354
14		$141,809	$22,900	$164,709	0.388	$63,907
15		$141,809	$34,900	$176,709	0.362	$63,969
16		$141,809	$22,900	$164,709	0.339	$55,836
17		$141,809	$22,900	$164,709	0.317	$52,213
18		$141,809	$22,900	$164,709	0.296	$48,754
19		$141,809	$22,900	$164,709	0.277	$45,624
20		$141,809	$34,900	$176,709	0.258	$45,591
21		$141,809	$22,900	$164,709	0.242	$39,860
22		$141,809	$22,900	$164,709	0.226	$37,224
23		$141,809	$22,900	$164,709	0.211	$34,754
24		$141,809	$22,900	$164,709	0.197	$32,448
25		$141,809	$34,900	$176,709	0.184	$32,514
26		$141,809	$22,900	$164,709	0.172	$28,330
27		$141,809	$22,900	$164,709	0.161	$26,518
28		$141,809	$22,900	$164,709	0.150	$24,706
29		$141,809	$22,900	$164,709	0.141	$23,224
30		$141,809	$34,900	$176,709	0.131	$23,149
					TOTAL PRESENT WORTH	**$8,812,201**